The SCIENTIFIC MONTHLY

VOL. LXV *August 1947* NO. 2

BRIGADIER GENERAL MERVIN E. GROSS

FIRST COMMANDANT OF THE AAF INSTITUTE OF TECHNOLOGY, WHO WAS KILLED IN A P-80 JET FIGHTER CRASH IN OCTOBER 1946.

See *Scientific Education for Air Force Officers*, page 94, and *In Memoriam*, page 102.

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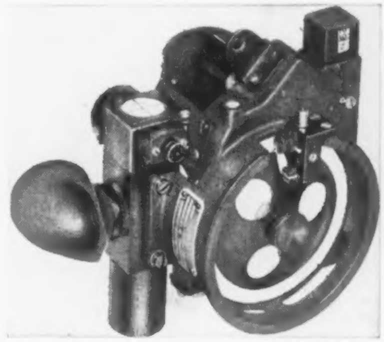

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THE SCIENTIFIC MONTHLY

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WILLARD LEE VALENTINE, 1904–1947

By DAEL WOLFLE

Executive Secretary, American Psychological Association, Washington, D. C.

WILLARD LEE VALENTINE, Editor of *Science*, died unexpectedly at his home in Alexandria, Va., on April 5, 1947. Sudden heart failure ended his career at the age of forty-two.

Dr. Valentine was born December 2, 1904, in Chillicothe, Ohio. There he received his elementary and high-school education. He attended Ohio Wesleyan University and received the A.B. degree in 1925. That summer he served as an assistant at the Munsell Color Research Laboratory in Baltimore. In the autumn he returned to Ohio Wesleyan as an assistant in mathematics and psychology. The following year he was promoted to the rank of instructor in psychology, a position he held for the next two years while continuing his graduate study under Professor F. C. Dockeray. In 1928 he moved to The Ohio State University. He and I were both new graduate students there that fall, and we had adjoining offices. In common with students everywhere, we enjoyed trying to reconcile our different viewpoints.

Under the direction of Professor A. P. Weiss he completed his graduate work that same year and received the Ph.D. in 1929. Ohio State Ph.D.'s were rarely retained on the permanent teaching staff, but Valentine was an exception. He was offered, and accepted, an assistant professorship. The year before, as a graduate student instructor, he had taught some of the small groups of beginning psychology students; now he assisted in directing the group of student instructors.

In addition to his purely administrative duties at Ohio State, Valentine prepared instructional materials to encourage similarity in the many introductory psychology classes. First he wrote an experimental laboratory manual, which went through several revisions as experience dictated changes and improvements. *Readings in Experimental Psychology* (Harpers 1931) was a first effort to prepare a collection of research reports that would introduce the beginning student to some of the active research problems in psychology and teach him the methods used to solve those problems. *Experimental Foundations of General Psychology* (Farrar and Rinehart, 1938, revised edition 1941) was a later and much improved collection of research papers prepared for the same purpose. Most of the papers in the first volume were rewritten by Valentine, not to write them down, but to write them for the elementary student. Four were original papers. As the author

WILLARD L. VALENTINE, 1904–1947

of one of the four, I noted with interest that Valentine rewrote everything in the later book. That was an improvement; the four original articles were much more difficult for students to comprehend than were the parts that had been rewritten.

Both books, and particularly the later one, found a wide usefulness in classes in many colleges and universities other than Ohio State. At the time of his death Valentine had returned to this early interest in making better teaching materials available; he had just completed a third edition of *Experimental Foundations of General Psychology*.

Dr. Valentine's research centered in the field of learning. Studies at Ohio Wesleyan were based on experiments in animal learning. His doctoral dissertation dealt with a problem in human learning. Postdoctoral research at Ohio State was in the field of infant behavior, where he was one of the collaborating group organized around Professor Weiss. During these days he developed an interest in motion-picture records of infant development. He was

concerned with theoretical as well as purely experimental problems in learning and contributed to the literature on mathematical characteristics of the learning curve.

Ohio State University promoted him from assistant professor to associate professor in 1932. In 1940 he moved to Northwestern University as professor of psychology and chairman of the department, a position he held until the autumn of 1945.

In 1937 Valentine was chosen as treasurer of the American Psychological Association. A year later he became business manager of the Association's publications. At that time the APA published five journals, with a combined total circulation of about 5,500 subscriptions. Between 1938 and 1945, when he resigned as business manager of publications for the APA, several new journals were added to the list, club-rate subscriptions were made available to members, and the total circulation grew to approximately 19,000 subscriptions.

At a meeting of the Board of Directors of the American Psychological Association held just a week before he died, Valentine asked for the privilege of resigning from the position of treasurer. The directors persuaded him to serve out the remainder of his term, which would have expired in 1950. He had for ten years been the Association's central figure in financial planning; the directors did not wish to lose his knowledge and counsel.

Valentine's editorial skill, coupled with his years of successful management of psychological publications, made him a logical choice for the editorship of *Science* when the American Association for the Advancement of Science assumed active control of that journal. He was offered the editorship in the fall of 1945. Northwestern University consented to his release, and in November he moved to Washington to begin planning his first issue of *Science*. He believed that *Science* had been too technical in its content, that it ought not to have the same type of content or the same function as a specialized scientific journal, and that it ought to contain material about science and scientists that would be of interest whether the reader was a chemist, a zoologist, or an anthropologist. He sought to remake it into a newsweekly of general scientific interest. In that effort he was achieving gradually increasing success until the time of his death. News items about scientists had become a more prominent feature, and articles of a general nature were more common. During 1946 and again in 1947 when Science Foundation bills were being considered in Congress, scientists were kept informed of their nature and progress through the pages of *Science*. Other legislation affecting scientists was summarized. Together with these changes in content went an improved and more readable format. At the end of his first year as editor, Valentine conducted a readership survey of a selected sample of *Science* readers. The result must have been very satisfying, for there were many favorable comments; he also received fan mail in substantial amounts.

Valentine's professional life consisted very largely of a life of service to his fellow psychologists. His books, his years of assistance to younger instructors at Ohio State and Northwestern, his work as treasurer of the American Psychological Association, and his management of the APA publications made him one of the most respected of American psychologists. When his ability was recognized outside psychology he moved into a position of larger opportunity for service to scientists of all fields. Death came in his prime, depriving science of an able worker and scientists of a valued friend.

SCIENTIFIC EDUCATION FOR AIR FORCE OFFICERS

By CLARENCE R. WYLIE, JR.

Since August 1947 marks the fortieth anniversary of the establishment of the precursor of the Army Air Forces, we called upon Professor Wylie to review the growth of scientific education of AAF officers within the army and in particular to describe the new AAF Institute of Technology at Wright Field, of which he is Acting Dean of the College of Engineering Sciences and Chairman of the Department of Mathematics. Dr. Wylie (Ph.D., Cornell, 1934), formerly Assistant Professor of Mathematics at Ohio State, served in the Propeller Laboratory at Wright Field during the war. Also a poet, his "In Memoriam" to General Gross appears on page 102 of this issue.—Ed.

ON September 3, 1946, when Lieutenant General Nathan F. Twining, Commanding General, Air Materiel Command, officially opened the Army Air Forces Institute of Technology with his address of welcome to its first class, the fourth stage in the evolution of scientific education within the AAF began. For 33 of the 40 years that have elapsed since the modest beginning of the AAF with the detailing of two enlisted men to aeronautical duty in June 1907 and the creation of an aeronautical division in the office of the Chief Signal Officer of the United States Army in August 1907, this program of scientific instruction has paralleled in its development the growth of the Air Force itself. The problems of one have been the problems of the other; the triumphs of one have been, in part, triumphs of the other; and the future of the Air Forces as a guarantor of national security and peace is in ever-increasing measure a matter of maintaining technical leadership through officer training such as that provided by the AAF Institute of Technology.

In 1907, nine years after the inception of the subsidized experiments of Professor Langley and four years after the Wright brothers' first successful flight at Kittyhawk, the great problem confronting the air-minded leaders of the United States Army was still that of getting a plane that would fly. Not until August 1909 when the Wrights delivered a plane which met the requirements of carrying two passengers and flying 125 miles at a top speed of 40 miles per hour was this first problem successfully solved. For the next several years all the energies of the youthful aeronautical division were concentrated on learning to fly, and training in the scientific aspects of aviation was not undertaken until 1914, when Captain Virginius E. Clark was sent to M.I.T. to study aeronautical engineering. This first phase in the evoluiton of scientific education of Air Force officers was further expanded during World War I; and, paralleling the much larger training programs for flyers, mechanics, and supply officers, a course in aeronautical engineering for army and naval personnel was established at M.I.T. in 1917. From this two small classes were graduated.

In 1918, as combat experience made it increasingly clear that the military usefulness of airplanes extended far beyond the functions of observation and reconnaissance, the air activities of the army were detached from the Signal Corps; and a Department of Military Aeronautics and a Bureau of Aircraft Production were established. In this period of reorganization and change the second stage in the Air Force's program of technological education was begun. At the suggestion of Colonel Thurman H. Bane and upon approval by the War Department, a School of Aeronautical Engineering within the army,

known as the Air School of Application, was established in 1919 at McCook Field, the army's new research and development center at Dayton, Ohio. The first class, which entered in November of 1919, consisted of but seven officers. When Congress created the Air Service in 1920 by consolidating the Department of Military Aeronautics and the Bureau of Aircraft Production, the name of the school became, quite naturally, the Air Service Engineering School.

Until the creation of the Institute of Technology, the course of instruction in the Engineering School was of a year's duration. Entrance requirements were very flexible; and although graduates of West Point, Annapolis, or recognized civilian colleges were preferred, it was possible for an officer to enter with only a high-school education, provided that by experience and personal study he had mastered the fundamental engineering sciences of mathematics, physics, mechanics, chemistry, and drafting.

Originally, to quote an early bulletin,

> The school was opened for the purpose of giving instruction to senior officers in the Army Air Service holding important posts of command in order to keep them up to date on aircraft developments and to make them more efficient in the administration of their various stations. In other words, this school attempts to bridge the gap between the technical and the non-technical officer.

The major divisions of the curriculum were:

Mechanics, Strength of Materials, and Materials Laboratory
Shop Work
Business Administration
Armament
Electricity
Thermodynamics and Engine Design
Theoretical Aviation and Airplane Design

In general, the courses were taken consecutively rather than concurrently, each subject being studied intensively for a relatively short period. The method of instruction was "applicatory;" that is, it consisted of student projects initiated and completed with a minimum of formal lecturing. There was no permanent faculty, and, instead, all the specialists of the Engineering Division of McCook Field, of which the Commandant of the School was also the Commanding officer, were what might be called consulting instructors.

The second epoch in the development leading to the AAF Institute of Technology ended in 1926 when Congress authorized the creation of the Air Corps and an accompanying five-year program.

At this time McCook Field was relocated on a larger and more suitable site donated by the businessmen of Dayton, and its name was changed to its present designation—Wright Field. The Air Service Engineering School now became the Air Corps Engineering School. Although the latter retained the one-year course and the general curriculum of the former, there were certain fundamental changes in philosophy and policy motivated by the increasing importance of science and the specialist in the development of air power. The original purpose of educating senior officers holding command positions was enlarged to include the training of younger men to fill positions in research and design within the Engineering Division. The theory of instruction was correspondingly modified. Increased use of the lecture method was begun, and the first step in the creation of a permanent civilian faculty was taken with the appointment of Ezra Kotcher, now Director of the AAF Institute of Technology, as senior instructor. In this new direction the school continued without interruption except for the years 1927–28 and 1939–40, until Pearl Harbor, when more urgent needs for trained personnel forced a suspension of classes until 1944.

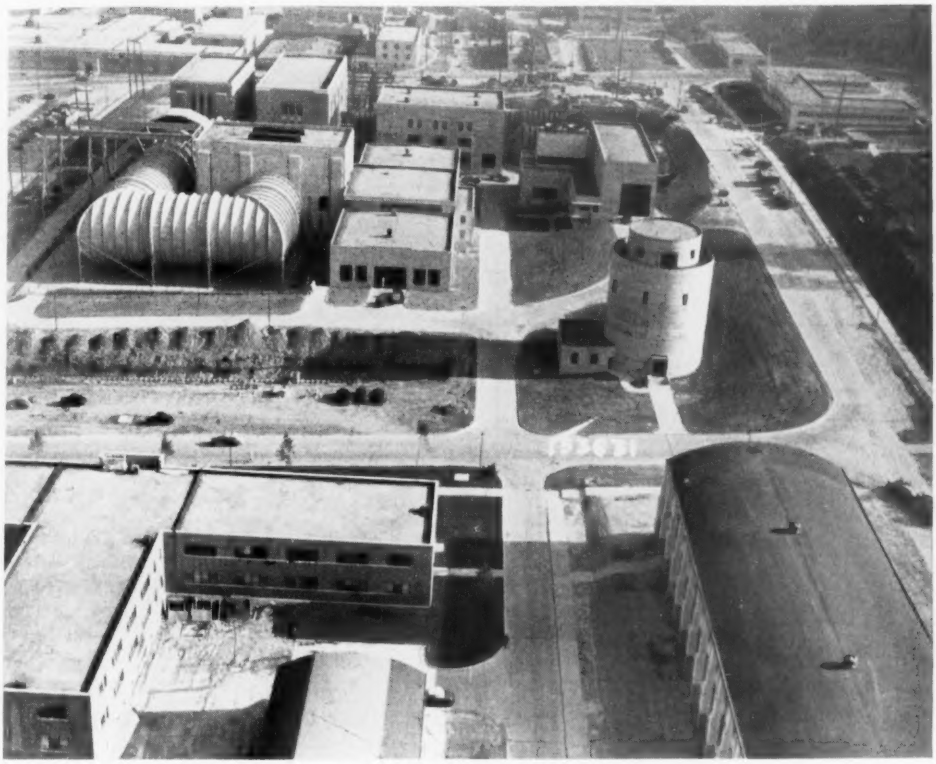
When the school was reopened, with the

name AAF Engineering School, in April 1944, the need for scientific leadership was so great that a year's course was a luxury that could not be afforded, and the efforts of the school until the end of the third phase of its development in 1946 were restricted to short-term refresher work in mathematics, mechanics, thermodynamics, and aerodynamics for men who were already engineering graduates.

MEASURED by the number of graduates from 1919 to 1946, the educational venture that has culminated in the AAF Institute of Technology has had only a limited success. Including graduates of the three- and six-month courses of 1944–46, 394 officers in all have received training. The achievement of its graduates is the proper measure of a school, however, and by this criterion the Institute of Technology inherits a tradition of which any institution might be proud. General Kenny was a graduate of the class of 1921, and General Doolittle a graduate of the class of 1923. General Chidlaw, director of all engineering research and development at Wright Field, and General Craigie, present chief of the Engineering Division of the Air Materiel Command, are also graduates. General Fairchild, present Commandant of the Air University, and General Gross, first Commandant of the Institute of Technology, were trained in the school. Other leaders of the AAF to whose professional development the school made its contribution included General Powers, General Whitehead, General Echols, and many more.

Inspired by the record of the Engineering School in training such men as these and conscious of the vastly greater need for leaders of similar technical competence in the future, the Commanding General of the Air Materiel Command in 1945 appointed a board of officers to investigate the problem of creating at Wright Field a technical institute to provide Air Force officers with advanced training in aeronautical engineering and related subjects as applied specifically to AAF problems. The work of this committee was reviewed and extended by a group of civilian scientists known as the Markham Committee: John R. Markham, Massachusetts Institute of Technology; William H. Pickering, California Institute of Technology; E. E. Scohler, California Institute of Technology; and T. H. Troller, Case School of Applied Science. The recommendations of this board called for a school to provide the AAF with a minimum of 200 technical graduates a year. Officers were to be trained not only in aeronautical engineering and the supporting sciences, but also in the field of business administration and logistics as applied to the supply and procurement problems of the AAF. The curricula were to be patterned, with necessary modifications to fit them to the needs of the AAF, after the aeronautical engineering and industrial administration courses of the leading civilian universities. Courses were, in general, to be offered by a faculty composed chiefly of civilian scholars who were to be not only thoroughly competent scientists but professional teachers as well. In order to give stability and continuity to the instructional program, it was recommended that the appointments of faculty members carry the same implication of permanent tenure that accompanies appointments in civilian institutions.

This reorganization of the engineering school coincided with an even more important and more far-reaching reorganization of the entire educational program of the Air Forces. For 1945 saw all the high-level educational ventures of the AAF integrated into what is now known officially as the Air University Command with headquarters at Maxwell Field, Ala. Thus when the AAF Institute of Technology was officially activated in 1946, although for obvious reasons it was de-



AIR VIEW AT WRIGHT FIELD

SHOWING THE TWENTY-FOOT WIND TUNNEL, PART OF THE CAMPUS OF AAF INSTITUTE OF TECHNOLOGY.

tached from Maxwell Field and assigned to the Materiel Command at Wright Field, it appeared as one of six schools composing the Air University, ranking with the Air Command and Staff School, The Special Staff School, the Air Tactical School, and the School of Aviation Medicine as a supporting school of the all-important Air War College. Under the broad educational program projected for the AAF, qualified officers will normally alternate periods of active duty with periods of study in one or another of these schools.

The immediate direction of the Institute of Technology was entrusted to Brigadier General Mervin E. Gross, a graduate of the class of 1933 of the Air Corps Engineering School, who was appointed Commandant, and to Ezra Kotcher, the senior instructor in the Engineering School from 1926 until Pearl Harbor, who was named Director. During the war Professor Kotcher, as a major in the AAF, was actively engaged in research and development projects in guided missiles and jet aircraft. Following General Gross's death in a P-80 crash in October 1946, Brigadier General Edgar P. Sorensen, who was Assistant Commandant of the Engineering School from 1926 to 1930 and more recently senior Air Force representative on the Army-Navy Munitions Board, became Commandant.

Following the recommendations of the Markham Committee, the Institute consists of a College of Engineering Sciences, of which Dr. Clarence R. Wylie, Jr., formerly of The Ohio State University and now Chairman of the Department of Mathematics of the Institute, is Acting Dean; and a College of Industrial and Engineering

Air Materiel Command Photo

BRIG. GENERAL EDGAR P. SORENSEN

COMMANDANT AAF INSTITUTE OF TECHNOLOGY.

Administration, of which Weldon B. Gibson is Dean. Dean Gibson was a member of the original board of officers that recommended the establishment of the Institute and during the war, as a colonel in the Air Corps, was in charge of requirements for spare parts, supplies, and equipment at the Air Materiel Command.

The faculty consists at present of 18 civilians and 6 officers. The civilian professors are for the most part former university professors who, by temperament and experience, are qualified to apply their knowledge to the practical problems of the AAF. Some were in uniform during the war and acquired their understanding of the technical needs of the Air Forces through their work as officers on engineering projects. Others served as civilian specialists in government laboratories, while still others worked as engineers for aircraft companies. The officers who are currently engaged in instructional work are all young men recently back from graduate school where they were sent under army auspices for advanced training in specialized fields. They are all well-qualified and enthusiastic lecturers and, although subject to the uncertainties of reassignment, are a welcome source of assistance during the growing period of the Institute.

In addition to the faculty proper, the specialists of the Air Materiel Command constitute an invaluable reservoir of instructional talent. Numerous special lectures and a few entire courses have already been presented by men not actually affiliated with the Institute, who have been released from a portion of their other duties to undertake such teaching. In return, faculty members of the Institute are from time to time called upon as consultants on problems in their special fields by engineers of the Materiel Command. In this way the choice of Wright Field as a location uniquely suited both to the needs and to the potential contributions of the Institute is justified, and host and guest alike are the richer. In the future, as the throes of organization and growth are left behind and a stabilized program emerges, it is contemplated that to an increasing extent the staff members of the Institute will interest themselves as specialists in the problems of Air Materiel Command and that correspondingly the superb experimental facilities of Wright Field will become available for faculty research. As a first step in this direction, the teaching schedules of the Institute already provide for a three-month period each year when a man will be relieved of teaching duties and, after taking his normal civil service vacation, will be able to spend at least two months in independent study and research, writing, or consulting work in one of the Wright Field laboratories.

THE curricula of the Institute, which now cover two years of work, each divided into four terms, have been constructed to be broad in scope and rich in fundamentals with a realistic understanding that it is impossible for an army officer to function as

a creative research scientist. The future of American military aviation requires not that military personnel undertake to make the scientific discoveries that must be made in order to maintain and advance our position of pre-eminence as an air power, but rather that they be able to sense in the pure research of civilian scientists elements of potential military value and that they be able to initiate, to direct, and to administer programs of research and development designed to exploit the military worth of such discoveries.

For this reason, the engineering curriculum of the Institute lays almost equal stress on advanced mathematics, mechanics, electrical engineering and electronics, thermodynamics, aerodynamics, and the application of all these to problems of design. To round out this work student officers in engineering also take occasional courses in war economics, industrial management, and procurement and supply. Students in the college of administration get an equally

Air Materiel Command Photo

CLARENCE R. WYLIE, JR.

ACTING DEAN, COLLEGE OF ENGINEERING SCIENCES, AND CHAIRMAN, DEPT. OF MATHEMATICS, AAFIT.

Air Materiel Command Photo

EZRA KOTCHER, DIRECTOR, AAFIT

broad training in accounting and finance, economics, management, production, procurement and supply, and law and, in addition, are required to take drafting and basic courses in all the engineering fields listed above except designing. Electives in both colleges are strictly limited.

The academic qualifications for admission to the Institute remain quite flexible. Basically, a man is required to have the mastery of mathematics, physics, chemistry, and drafting normally attained in the first two years of a standard engineering course. For students of administration, a proficiency in these same subjects, although on a lower level, is demanded, with economics or an equivalent business subject replacing drafting as a requirement. In general, a liberal policy of evaluating service experience, training obtained in army schools and correspondence courses, such as USAFI, and in granting entrance credit

Air Materiel Command Photo

WELDON B. GIBSON

DEAN, COLLEGE OF INDUSTRIAL AND ENGINEERING ADMINISTRATION, AAFIT.

through examination has been adopted.

Although the ultimate goal of the Institute is to conduct its instruction (after a necessary minimum of review) entirely at the graduate level, somewhat after the pattern of the Naval Postgraduate School[1], it is both necessary and desirable that young officers whose undergraduate work was interrupted or deferred by the war should be given every opportunity to complete their formal education. Provisions have been made for officers who are accepted for the regular army to return to their original schools and complete the requirements for their degrees. Many of these men, especially those whose early work was not along engineering lines, prefer training in the Institute in actual contact with AAF problems, however.

[1] Cf. Root, R. E. Mathematics and Mechanics in the Postgraduate School at Annapolis. *The Amer. Math. Monthly*, April 1943, 238.

As a result of this state of affairs, the 181 officers in the present class of the Institute form a highly heterogeneous group. In rank they range from lieutenants to colonels; in age they range from twenty-two to forty-five. In educational background they range from men with little more than a year of college to men who already possess a degree. In each college a few well-qualified members of the latter group were permitted to enroll in a special one-year course and will graduate this month. The vast majority, graduates and nongraduates alike, are enrolled in the two-year course, however.

The number of students without degrees emphasizes one of the persistent and as yet unsolved problems of the Institute: Shall the curricula be organized in such a way that authority to grant degrees to men completing them can appropriately be sought? Officers whose education was disrupted by the war quite naturally desire a degree to mark their achievement in the Institute. On the other hand, in terms of the specific objective of increasing the technical competence of officers of the AAF, many subjects, especially those with a liberal or cultural character, that would have to be in any curriculum worthy of a recognized or accredited degree seem irrelevant and unjustifiable in terms of the time and faculty required for their presentation. At present it seems desirable to compromise between these two extremes by planning the curricula and establishing entrance requirements with the needs of the AAF for scientific personnel the only consideration, but at the same time making provision for conferring degrees upon those members of each graduating class whose work in the Institute, together with the work of college caliber done elsewhere, equals in amount, variety, and quality the proper requirements for a degree. Under such a plan, not all student officers would be candidates for a degree, for entrance

requirements would be based solely upon qualifications necessary for successful work in the Institute and not upon the additional subjects required for a degree but not offered in the school. To such men a degree might, perhaps, be granted at a later date if, through further study in civilian colleges near which they happen to be stationed, their deficiencies be removed. At present, no authority to grant any degrees is vested in the Institute.

Among other problems which have yet to be completely solved is the matter of basic laboratories. It is strange, perhaps, but true that, although the AAF Institute of Technology is located in the greatest aeronautical laboratory in the world, the acquisition of elementary laboratory facilities has been one of its chief concerns. For instructional purposes in basic courses in physics, electrical engineering, and materials testing, the elaborate and specialized equipment to be found in the Wright Field laboratories, even if it could be made available to the large groups involved, is quite useless. As a result, the Institute, like many another scientific institution, has found it necessary to create its basic laboratories *ab ova*, as it were. At more advanced levels, where existing equipment is relevant to course content, the problem of making it available at the proper time to the appropriate classes without completely disrupting experimental work actually in progress requires a tremendous amount of planning and cooperation between the Institute and the various laboratories of the Engineering Division. At present it is contemplated that the summer quarter of each year will be devoted to professional work in the Wright Field laboratories and that high-level laboratory work will be accomplished through full-time participation in the scheduled experimental work of the Air Materiel Command.

In addition to its primary instructional objective, the Institute of Technology has several other important functions to perform. Under a delegation of authority from the Air University, the Graduate Section of the Institute has the responsibility of administering specialized graduate training of AAF officers in civilian universities. This includes the screening of applicants for such studies and the monitoring of their progress in the institutions to which they are assigned. At present about 250 officers are pursuing graduate studies in technical fields of special importance to the AAF. Many of the country's leading engineering schools are participating in this program. In most cases, the universities simply admit the officers to their regularly scheduled graduate classes. In some cases, notably at the University of Michigan, where a course in guided missiles based on restricted material furnished by the AAF was created, an entire curriculum open only to army officers has been established.

A second function of the Graduate Section is the administration of the AMC Civilian Graduate Center. This is a cooperative educational venture with The Ohio State University through its Twilight School. Using Institute classrooms and office space, Ohio State presents selected graduate courses in the engineering sciences, business administration, and psychology. These are open to all properly qualified civilian and military employees of the Air Materiel Command and are designed to enable AMC personnel to secure masters' degrees if they so desire. In general, courses are presented by members of the faculty of Ohio State, temporarily resident in Dayton, although engineers from Wright Field and professors from nearby colleges, including the Institute, have on occasion been retained to offer particular courses.

Somewhat less developed but potentially of great value is the program of the Extension Section of the Institute. As its name suggests, the Extension Section is engaged in preparing technical correspondence-type

courses to supplement the training of National Guard and organized Reserve Corps officers. These courses, which are offered through the Air University, are designed to keep officers not on active duty abreast of important developments in the scientific aspects of air warfare.

With the creation of the Air University and the AAF Institute of Technology higher education within the Air Forces can be said to have reached its majority. Whether graduates of future classes will be able to cope as successfully with the problems of the "atomic age" or the "supersonic age" as their predecessors did with the problems of the "great beginning," time alone will reveal. The desire to keep America strong and safe is as great an incentive as ever to faculty and students alike; and although we cannot agree with the unknown chronicler of the old Engineering School who wrote in the early twenties, "There certainly is nothing more valuable than the realization on the part of a student that practically all knowledge has been laid down in written books and that this can be obtained by the student by a personal application," we shall strive to teach our graduates after they have mastered some of the knowledge "laid down in books" to encourage, to appraise correctly, and to apply fruitfully to the problems of national security the new knowledge to be found beyond their texts.

IN MEMORIAM

Brigadier General Mervin E. Gross

His wings are folded now. He lies asleep
Beneath the sky he loved and sought to make
A second highway for the needs of men.
Speak it majestically, that dream of dreams,
Mark how it made him fellow to the brave
Who in all ages, heedless of themselves
Or of their fate, choose as their cause the one
Most worthy of their daring and their strength.

His wings are folded, and we mourn his loss.
Yet are we certain that beyond our own
A wider sky awaits his venturing,
As here, because we knew him, worked with him,
And saw our common future through his eyes,
We have a greater goal toward which to press.

Clarence R. Wylie, Jr.

CRUMBLING ROCKS

By RAYMOND E. JANSSEN

Professor Janssen (Ph.D., Chicago, 1939) is head of the Department of Geology, Marshall College. Long interested in the popularization of science, he has written numerous books and articles in this field. He has designed geological exhibits for the Chicago Natural History Museum, the Chicago Century of Progress Exposition, Rosenwald Museum of Science and Industry, and the Texas Centennial Exposition. His research has been in paleobotany.

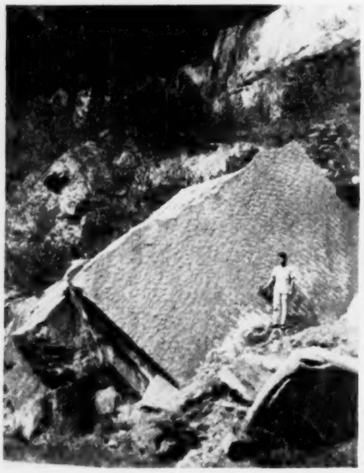
For the mountains shall depart, and the hills be removed.—Isa. 54:10.

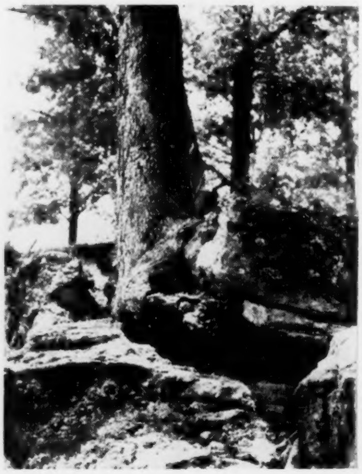
PROBABLY there is nothing in nature more grand and imposing than a lofty mountain, its towering peak snow-capped and glistening like a diadem in the sunlight, its enormous bulk fashioned from massive, solid rock. By contrast, nothing else on earth seems to be more firm and stable. It is not surprising, therefore, that such vistas have been an inspiration for poets, authors, and prophets throughout the ages. We find numerous references, particularly in the Bible, to the everlasting qualities of the hills and the mountains. The ancient prophets exalted their God by comparisons of his strength and endurance with those of the rocks and the mountains; they admonished the people that his steadfastness was even greater than that of these eternal structures. Even in modern parlance there are numerous sayings to the effect that something is "as old as the hills" or "as hard as a rock."

On the other hand, if one will pause to think a moment, it is self-evident that even the hardest rocks are subject to breakdown and decay. There are various examples of this on every hand. Inscriptions on old tombstones are slowly obliterated after many decades; surfaces of old stone edifices crumble away; stone steps of public buildings are gradually hollowed out by the constant tread of leather soles. Along country roads where the highway has been cut through rock strata, the stone soon loses its appearance of freshness, pitted surfaces develop, and pieces of rock slough off to collect in heaps at the base. If changes such as these occur within a few years or decades, infinitely greater ones must take place over periods of thousands or millions of years.

Detailed study of such phenomena has shown that over long periods of time all rocks exposed at the earth's surface are readily altered. For the most part, these changes are accomplished, directly or indirectly, by the action of the atmosphere and precipitation, and hence are appropriately termed rock-weathering. Depending upon the prevailing weather and climate and kind of rock in any given region, the alteration process may be dominantly chemical, mechanical, or a combination of both. In humid regions the rock surfaces become dull and stained, crumbly and pitted, as a result of chemical action of the moisture upon the minerals comprising the rocks, causing the latter literally to decay or decompose. It is this same process that causes old tin cans or the unpainted surfaces of bridges and other structures to flake off in the form of rust. In arid regions, on the other hand, the surfaces of the rocks may remain reasonably fresh, but cracks and fissures appear, and thin slivers and shells break away from the surfaces. Because here the air is relatively dry, the process is essentially mechanical in nature. Both processes, however, are forms of rock-weathering.

As a result of either of these processes or both of them, solid and firm rock ultimately crumbles into small pieces, grains, and dust. If the exposed rock forms the side of a cliff, steep valley, or mountainside, the weathered





Photos by author

WEATHERING AND EROSION

Upper left, EARLY STAGES OF WEATHERING AND EROSION ARE SHOWN BY THIS GREAT SLAB OF RIPPLE-MARKED SANDSTONE WHICH HAS FALLEN FROM A CLIFF NEAR ASHLAND, KY. *Upper right*, SERIOUS DEVELOPMENT OF EROSION IN SOIL MANTLE ON CUT-OVER HILLSIDE NEAR HUNTINGTON, W. VA. *Lower left*, ENORMOUS TRANSPORTING POWER OF GLACIAL ICE IS INDICATED BY THIS GREAT BOULDER WHICH WAS MOVED UPHILL FROM ITS ORIGINAL POSITION ABOUT 20 MILES AWAY IN YELLOWSTONE NATIONAL PARK. *Lower right*, GROWING ROOTS OF AN OAK TREE PRYING UP A SLAB OF ROCK IN THE OZARKS OF MISSOURI.

and loosened fragments slide or creep downgrade to build up heaps of debris, called talus, at the base of the parent rock mass. In some mountainous regions such heaps of slide-rock finally become so great as to bury the whole mountainside. If the bedrock is only gently inclined or essentially horizontal, the small fragments remain scattered on the surface, eventually weathering into smaller and smaller particles to form the mantle of soil that characteristically covers extensive areas of the earth's surface. In any region where soil lies on the surface, observation shows that with depth it grades downward into coarser and coarser fragments until the parent bedrock is reached. Such depths may, in various regions, be a matter of only a few inches or of hundreds of feet.

Because this mantle of broken rock and soil consists of relatively small particles, it is readily carried away by such mechanical forces as wind, running water, or ice, giving

rise to the familiar phenomenon known as erosion. Thus rock-weathering and erosion operate hand in hand to break down the solid rock and carry it away bit by bit to lower levels and finally to the sea. Through these combined processes, operating continuously through the ages, mountains are worn low and continental areas of past times have been literally washed away. Geologically, such events are of little moment in themselves because new lands and new mountains have continually been rebuilt or re-elevated from time to time to take the place of those that have been destroyed. From the human viewpoint, however, rock-weathering and the resulting erosion are of tremendous consequence, particularly where agriculture and related industries depend upon the use of the soil.

In nature, rock-weathering and erosion more or less keep pace with each other, thereby insuring retention of the soil mantle in regions where it has been developed. Here ground water and air, penetrating down-

Gray Brothers photo

UNEQUAL RESISTANCE OF ROCK STRATA

IN HUMID REGIONS SUCH CURIOUS FORMATIONS RESULT FROM OVERLYING ROCK LAYERS BEING MORE RESISTANT TO WEATHERING THAN THE LOWER ONES. NEAR EUREKA SPRINGS, ARK.

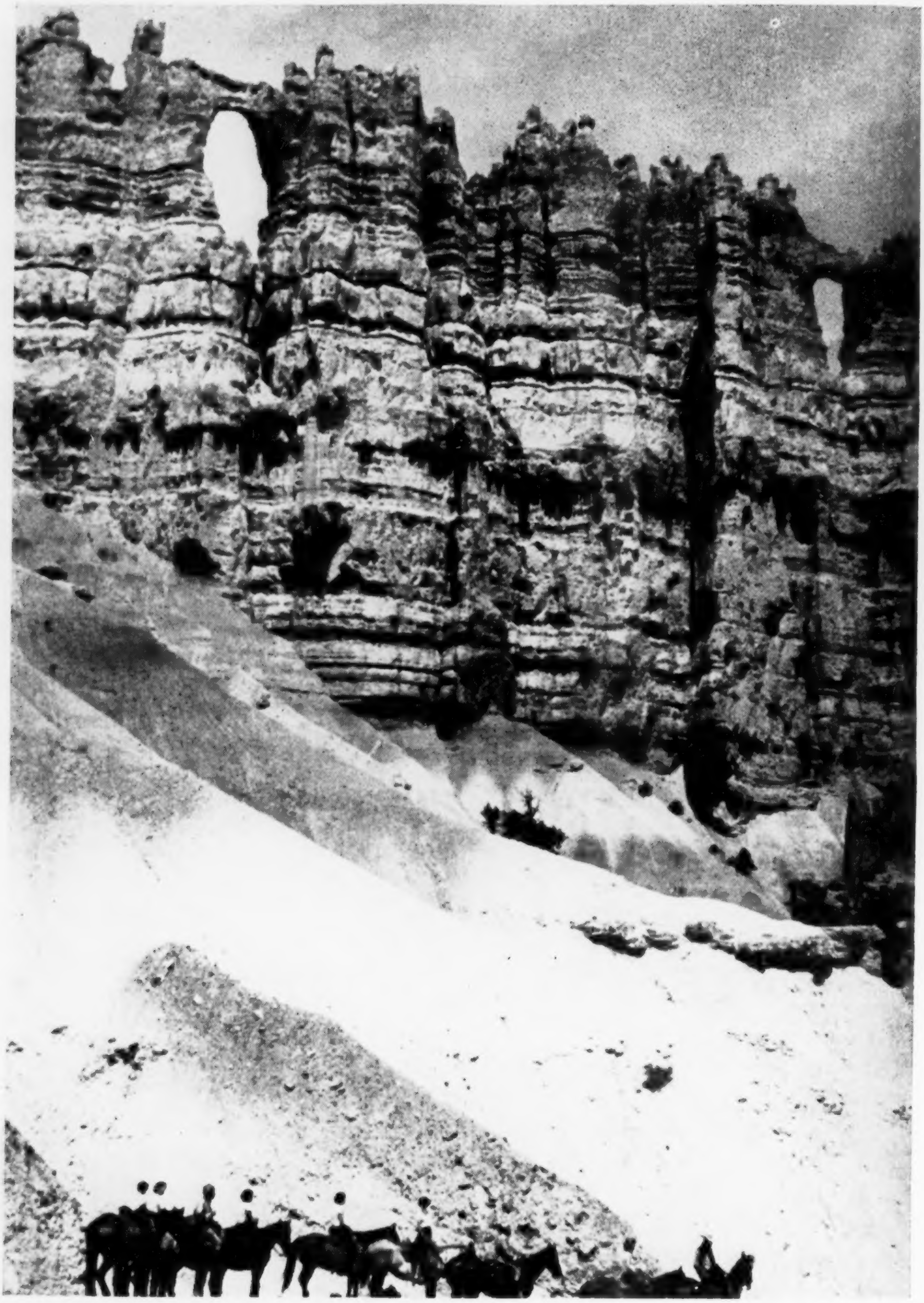


Photo courtesy Chicago & Northwestern Ry.

BEDROCK WEATHERING

RAIN AND WIND COMBINE THEIR FORCES TO BREAK DOWN MASSIVE ROCK IN BRYCE CANYON NATIONAL PARK, RESULTING IN ENORMOUS HEAPS OF TALUS, OR SLIDE-ROCK, AT THE BASE.

Photos by author

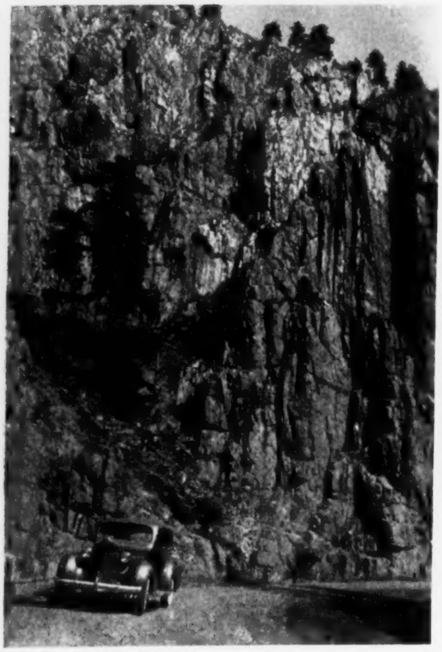
CHEMICAL WEATHERING OF SANDSTONE

Left, SOLUTION HOLES ALONG BEDDING PLANE OF OVERTURNED SANDSTONE AT CASCADE CAVERNS, KY. *Right,* THINLY BEDDED STRATA OF UNEQUAL RESISTANCE PRODUCE ALTERNATING RIDGES AND DEPRESSIONS ON WEATHERED SURFACE NEAR ASHLAND, KY. NOTE SCALING-OFF OF MASSIVE LAYER NEAR BASE.

ward through the interspaces of the soil, slowly weather the bedrock beneath, breaking it into smaller particles, even though the rock is blanketed by many feet of mantle. If the topsoil is not carried away too fast, this slow weathering of the rock beneath continues in pace with the normal erosion of the soil above. Thus, under normal conditions in most areas of the world, the soil mantle, as a unit, would remain essentially static were it not for improper agricultural practices that permit erosion to operate faster than new soil can be formed by weathering. If researchers in rock-weathering could discover practical means whereby natural weathering could be greatly speeded, some of our serious erosion problems might be solved.

Theoretically, rock-weathering is considered by geologists as being merely the process whereby massive rock is disintegrated or decomposed into smaller and finer particles, regardless of the manner in which it is accomplished. Erosion, on the other hand, involves the removal of these particles from their original sites to any other location, their ultimate destination usually being the sea. From a practical standpoint, however, it is not always possible to differentiate clearly between weathering and erosion, since the two are so interrelated that they usually aid and abet each other. This is particularly true where so-called mechanical weathering appears to be the dominant factor. Because rock is a relatively poor conductor of heat, the sun's rays cause exposed surfaces to become heated and expanded more than the interior, resulting in strains that weaken the rock. At night there may be a reversal of this condition, the rock surfaces

losing their heat and becoming colder than the inside. Such expansions are characteristic of desert and semiarid regions where temperatures may be quite high in daytime and correspondingly low at night. As a result of these expansions and contractions over long periods, the rock finally yields by shelling off its outer layer. As fresh surfaces are exposed, the process is repeated. Although such action may be primarily mechanical, it is aided by chemical reactions when small amounts of moisture enter the cracks developed in this way and further the decomposition of the mineral matter comprising the rock. The loose shells of rock which thus fall away from the parent mass are not completely weathered, however, and may lie for many years on the ground before they are finally broken into particles small enough to be picked up by erosion agents and carried away. The great structure known as Half Dome, in Yosemite National Park, exhibits this form of weathering in enormous degree.



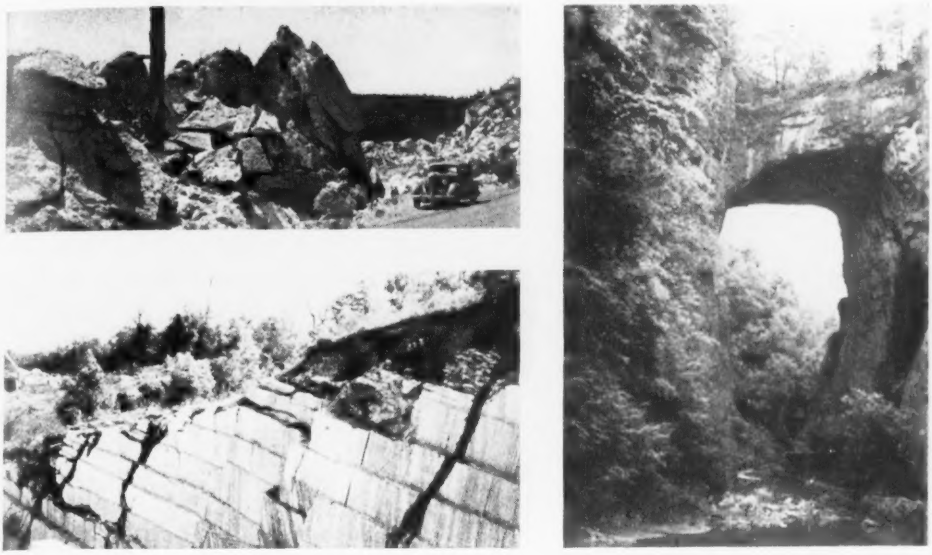
Photos by author

CHEMICAL WEATHERING OF GRANITE

Above, LARGE BOULDERS HAVE BEEN SMOOTHED BY RAIN-WASH ON A HILLTOP NEAR PIKE'S PEAK, COLO. *Below*, WEATHERING CONTROLLED BY JOINT CRACKS IN MASSIVE GRANITE OF BIG THOMPSON CANYON, COLO.

CLOSELY related to the foregoing process is that wherein water enters the crevices and pores of rocks and becomes frozen when the temperature drops. The expansion of the ice may exert sufficient pressure to pry the rocks apart, and, with alternate periods of thawing and freezing, great chunks of rock may be loosened and fall away from the main rock mass. In the same way, the roots of trees penetrating down into small rock fissures may exert sufficient force while growing to lift and pry away large slabs of rock. In addition, the mere difference in physical characteristics of alternating layers of rock may contribute to their disruption. Common examples of this may be seen wherever there are overhanging cliffs. Here soft, or more easily weathered, strata of rocks are topped by more resistant layers. The former, in weathering, are cut back under the overlying layers, eventually contributing to the downfall of the harder layers.

Theoretically, mechanical weathering can be distinguished from chemical weathering. The former is simply the breakdown of the parent rock mass into smaller pieces of vary-



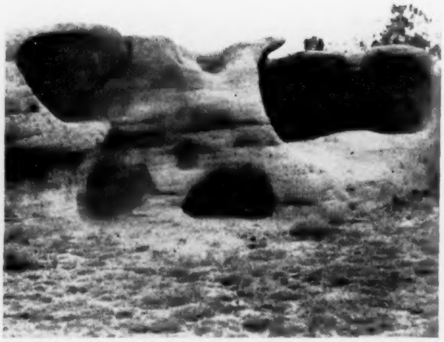
Photos by author

CHEMICAL WEATHERING OF LIMESTONE

Upper left, WEATHERING OF TUFA ROCKS ON SURFACE OF GROUND BY ATMOSPHERIC AGENTS IN YELLOWSTONE NATIONAL PARK. *Lower left,* SUBSURFACE WEATHERING ALONG CRACKS IN MASSIVE LIMESTONE, AS EXPOSED IN A QUARRY NEAR ST. GENEVIEVE, MO. *Right,* GREAT NATURAL BRIDGE OF VIRGINIA, DEVELOPED BY SOLUTION UNDERGROUND, PRODUCING A CAVERNOUS TUNNEL, THE ROOF OF WHICH SUBSEQUENTLY COLLAPSED EXCEPT FOR THE SPAN WHICH CONSTITUTES THE BRIDGE.

ing size and shape, enabling them to be moved by gravity or by eroding agents. Chemical weathering, however, involves an actual chemical change in the composition of the minerals comprising the rocks. Air and water, particularly if combined with carbonic acid from decaying vegetation, are powerful decomposers of rock materials; hence these agents literally tend to eat away the rock minerals. If any part of the mineral constituents of a rock mass is thus decayed away, the remaining structure may become so porous and weakened as to be much more easily attacked by mechanical processes. Only under very limited conditions are rocks completely weathered solely by one or the other means. Usually both forces operate together. It can be readily understood that when rocks are disintegrated by mechanical means, the smaller fragments expose a greater total surface area to the attack of chemical agents, permitting the latter to perform their work more effectively. And this, in turn, may quicken further mechanical breakdown. Some types of rocks and minerals, such as limestone, marble, salt, and gypsum, are quite susceptible to chemical attack; whereas others, such as shale, quartzite, and many volcanic rocks, are not and are therefore broken down principally by mechanical means.

Having been weathered, all rock particles are subject to transport, technically called erosion, whereby they are removed to other locations and ultimately to the sea. Depending upon the region, the erosion agents are wind, ice, or water. Operating most effectively in arid regions, the wind picks up the smaller weathered particles, such as dust and fine sand grains, often carrying them great distances before dropping them again. During the exceptionally dry periods of 1934–36, enormous dust storms, originating in the Great Plains of the United States,



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WIND ABRASION OF SANDSTONE

Above, FAMOUS BALANCED ROCK AND MUSHROOM ROCK, IN GARDEN OF THE GODS, COLO., OWE THEIR SHAPES TO THE ABRASIVE POWER OF THE WIND, WHICH HAS BEEN GREATEST NEAR THEIR BASES. *Lower left*, SPIRES DEVELOPED IN UPENDED STRATA IN THE GARDEN OF THE GODS ARE THE RESULT OF COMBINED MOISTURE AND WIND ACTION. *Lower right*, CAVES DEVELOPED BY SIMILAR AGENTS IN HORIZONTAL BEDS NEAR WALSENBURG, COLO.

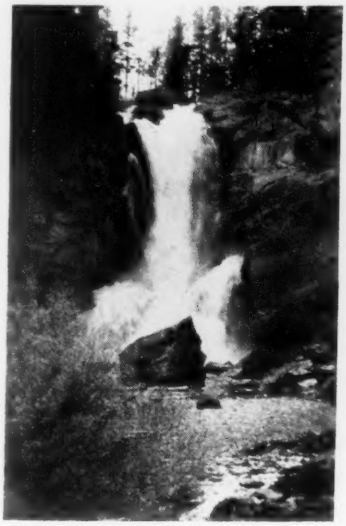
swept eastward across the continent. At Chicago, Detroit, and farther east, these storms were of such intensity as to black out the sun at midday. In some instances, the storms raced onward over the Atlantic, and sailors on ships at sea actually swept the dust of our Western prairies from their decks.

The wind, as an erosion agent, may also do much weathering. The loose sand grains, as they are blown along, may be hurled against projecting masses of rock with such force as to abrade, or wear away, their surfaces by a natural sandblast. Since the wind usually cannot lift sand grains very high from the ground, most of the sandblasting

action occurs within a few feet of the ground. This results in undercutting of the rocks to produce many curious rock formations, such as "toadstool rocks," balanced rocks, and oval caves in cliffsides. Oftentimes telephone poles and fence posts are cut off near the ground line by such sandblasting.

Running water, because of its almost universal distribution, is generally conceded to be the most important erosive agent. Most readily understood of all geologic processes is the part that surface streams play in land erosion by carrying away in suspension most of the weathered products of their drainage areas. In order to study the transporting power of streams, gauging stations are maintained near the mouths of many large rivers. In this way it has been determined that the Mississippi River normally carries more than a million tons of sediment daily to the Gulf of Mexico. Less well known, however, is the fact that these suspended particles of sediment may themselves act as further agents of weathering, as do the wind-carried particles. While being swirled along in the streams, the grains strike against the sides and the bedrock of the stream channels, grinding off additional particles of rock. It is also recognized that streams may transport stones that are too large and heavy for them to carry by suspension. They do this simply by rolling or buffeting them along their beds. Because of their greater gradients, tiny mountain streams may do this even more effectively than large, sluggish rivers. Frequently such stones roll into irregular depressions of the stream bed. If they are too heavy to roll out of the depression again, they may be swirled around and around in it, resulting in the grinding out of deep hollows, termed potholes. A long series of these may be spaced so close together as to coalesce, or cut into one another, eventually lowering the stream bed.

Any stream, whether it be on the surface or underground, and depending upon the kind of rock over or through which it is flowing, may also dissolve the rock. This is most pronounced where subsurface streams flow through crevices in limestone or other solu-



Photos by author

STREAM ABRASION

Left, A LARGE BOULDER, RECENTLY BROKEN FROM THE STRATA AT A WATERFALL IN GLACIER NATIONAL PARK, HAS NOT YET BEEN REDUCED BY ABRASION. *Right* BOULDERS IN ANOTHER STREAM HAVE BEEN GREATLY ABRADED AND ROUNDED BY IMPINGEMENT OF STREAM-BORNE PARTICLES AGAINST THEM.

ble types of rocks. This is, of course, a chemical action wherein the rock is weathered and carried away immediately in solution. All our large and beautiful caverns, such as Carlsbad, Mammoth, and Luray, were hollowed out by extended enlargement of cracks in the limestone by this dissolving power of running water.

Even nonflowing waters, such as the sea itself, are powerful weathering and eroding agents along the shores where they come into direct contact with the land. Rocky sea cliffs are battered to pieces by the onslaught of the waves. This is accomplished largely by the air that occupies the crevices in the rocks becoming compressed when the waves slap against it. The compressed air then tends to spread the rocks apart, eventually weakening them to the crumbling point. The broken rocks fall to the beach, where the waves pound them into fragments small enough to be carried out to sea by the undertow and alongshore currents.

In some respects, ice may be the most powerful eroding agent of all, particularly in regions where it occurs as enormous glaciers. Because of its rigidity, ice offers greater resistance than does either water or wind; therefore, when glacial ice moves over rock surfaces it may actually gouge out rocks that neither wind nor water could easily reach. The rock fragments thus gouged out may then become frozen in the bottom of the glacier and abrade the surfaces over which they move. In this way the glacier acts like a gigantic piece of sandpaper, grinding down the lands over which it passes. Also, in contrast to flowing water, which receives its momentum from gravity, glaciers may actually move uphill, wearing off the tops of hills and mountains as they ride up and over them. The method of uphill movement of ice may be visualized by likening a glacier to a string of railroad cars that are being pushed upgrade by a locomotive. The glacial ice accumulates from compacted snow that has fallen in the region of greatest precipitation. After a sufficient thickness of ice has thus been mounded up (usually several hundred to a thousand feet or more), it begins to move under its own weight, continuing to move thereafter as long as snow continues to be added at the accumulation point. The pressure thus created may cause the extremities of the glacier to move uphill if any elevations stand in its path. Thus the forward end of a glacier may act like a gigantic plow as it is shoved along.

Valley glaciers, those long, narrow rivers of ice that characteristically move down the sides of high mountains, are enormous carriers of rock debris. As they slowly wind their way down through the valleys, the flowing ice tends to conform to the valley shapes; but because the ice is nevertheless rigid, it cuts away at the sides and bottoms of the valleys, ever widening and deepening them by abrasion against the rock. As the valleys are cut wider and deeper, the upper parts of the valley walls may be left so poorly supported that slides and avalanches catapult down upon the glaciers from overhead. This material, often consisting of rocks and boulders of immense size, then rides along on top of the glaciers as though on great sleds. In this way rocks larger than houses can be carried along by the moving ice, a feat impossible for wind or water to accomplish.

Since, by definition, rock-weathering is the process of disintegrating or decomposing the rock into smaller pieces, and erosion is that of carrying these particles away, it should follow that the two processes are distinct in themselves. Yet, when one observes these activities taking place, it is virtually impossible to draw sharp lines between them. At what point do wind, water, and ice cease to break rock and, thereafter, merely transport it? The two processes may actually work simultaneously, and further

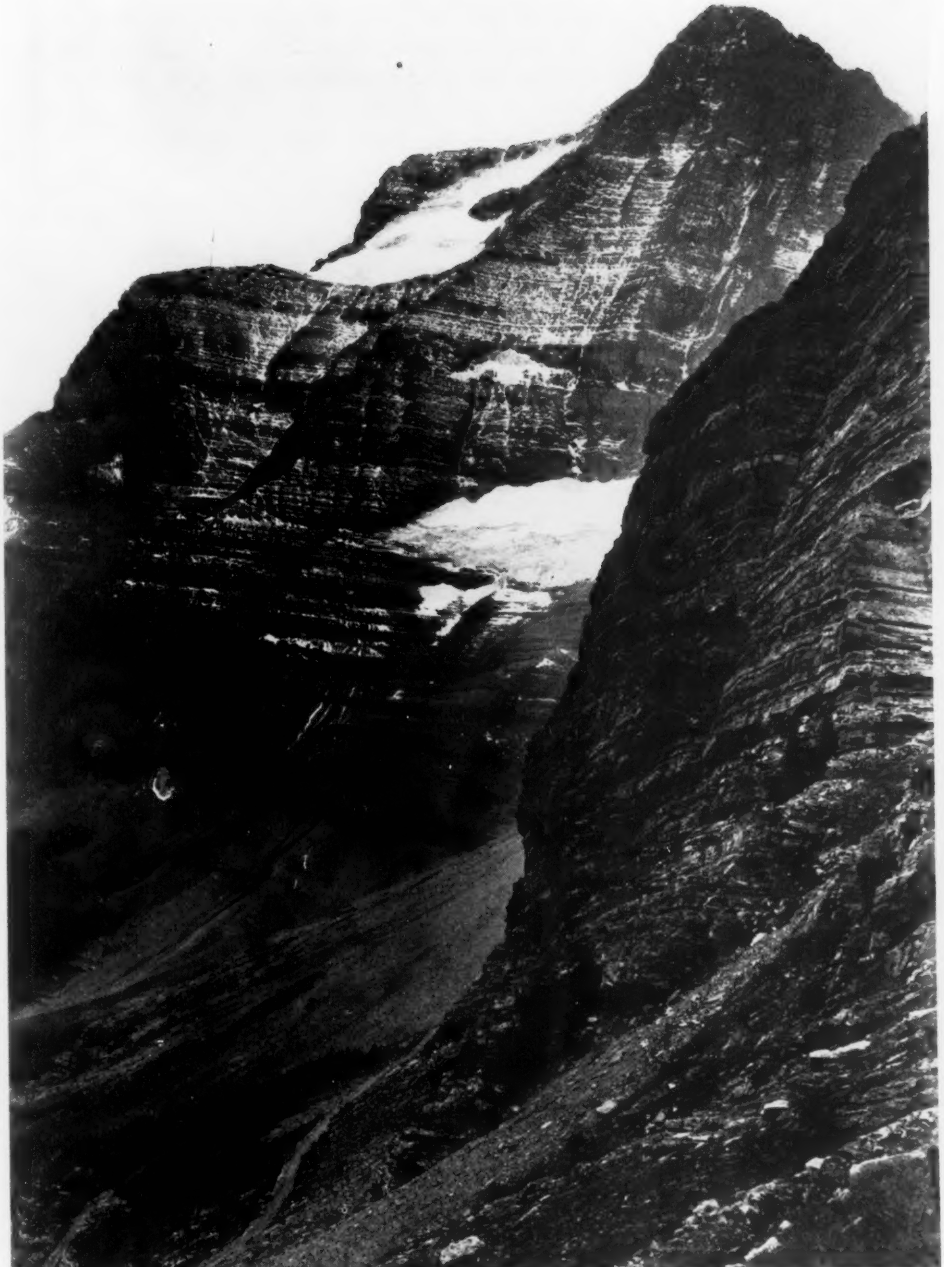


Photo courtesy National Park Service

ROCK PILED ON ROCK

THE DESTRUCTION OF MOUNTAINS IS WELL ILLUSTRATED BY GOING-TO-THE-SUN MOUNTAIN, IN GLACIER NATIONAL PARK, WHERE COUNTLESS ROCK LAYERS, HERE EMPHASIZED BY THE SNOW, ARE BEING SLOWLY WEATHERED AWAY AND CARRIED TOWARD THE SEA FOR ACCUMULATION OF STRATA OF A FUTURE AGE.

weathering may continue while the fragments are being transported. Only in the case of chemical weathering, wherein the rock material is completely dissolved and combined with the moving water, does weathering cease before final deposition in the sea. It is also true that neither weathering nor erosion could long continue without the other. Without weathering there would be no rock particles to be transported; and without erosion the weathered fragments would accumulate to such depths that the agents of weathering could not penetrate beneath the debris, and further weathering would cease. We have only to study the surface of our moon in order to visualize a condition wherein weathering and erosion do not occur. Because there is no atmosphere and no water on the moon, its surface remains unchanged except for the impact of falling meteors.

The profound effects resulting from the combined action of weathering and erosion account for nearly all the geologic changes that occur on the surface of the earth. The only exceptions are the processes of volcanism, faulting, and regional uplift, wherein new lands may be built and old ones shifted in position. But even these may be, in part at least, an indirect result of weathering and erosion. It is evident that, after vast lands and mountains have been eroded and the materials that comprised them have been deposited in the sea, a redistribution of weight has occurred. The lands have become lighter from the loss of material, and parts of the sea bottom have become heavier by the addition of these sediments. The added weight on the sea floor appears to cause it to sink, yet sinking toward the center of the earth cannot continue indefinitely because of its already greater density. The pressure, therefore, may be distributed laterally to the adjacent lands, apparently causing re-elevations. In this way, new mountains may be born or old ones uplifted. Then the cycle begins anew, for the recently elevated lands are at once attacked by weathering and erosion agents. Such cycles are the basis of subdividing geologic time, each major uplift marking the end of one period, or era, and the beginning of a new one. It can also be seen that the same grains of sand and silt may be used over and over again during successive periods of the earth's history. The grains of sand carried down from the heights of the present Rockies by the mighty Colorado River are used en route for the cutting of the Grand Canyon, finally being deposited in the Gulf of California. Here they will be consolidated into rock layers that in some future age will be uplifted to make new lands, whereupon they will once again be subjected to weathering and erosion and be carried downward to another sea. Although millions of years may have elapsed, the individual sand grains may even retain their identity in form and substance. Thus it is paradoxically true, perhaps, that the rocks are both ephemeral and everlasting!

To weathering and erosion, then, may be attributed nearly all those natural features of the earth considered beautiful in the eyes of man: the towering mountains, peaceful valleys, sweeping hills, broad plains, and dashing waterfalls. There are few individuals who can look upon beautiful scenery without experiencing some inward feeling of emotion at the wonders displayed before them. Such vistas may at first appear mysterious and meaningless but, upon study and contemplation, may be read like the pages of a book. It is the mighty history of an ever-changing earth wherein rock piled on rock is slowly crumbled away, only to be rebuilt from the products of its own destruction into new rocks of some succeeding age. The words of the prophet, written several millennia ago, still ring with truth:

> The everlasting mountains were scattered: the perpetual hills did bow: his ways are everlasting.—Hab. 3:6.

THE IONOSPHERE*

By J. H. DELLINGER

Dr. Dellinger (Ph.D., Princeton, 1913) has been a physicist at the National Bureau of Standards since 1907. He is now chief of their Division XIV, Central Radio Propagation Laboratory. He has had a distinguished career in radio, having represented the United States at many international radio conferences. He is Vice-president of the International Scientific Radio Union and Chairman of the Radio Technical Commission for Aeronautics.

THE ionosphere is the frontier between geophysics and astronomy. Its exploration is providing evidence and elucidation of the control of geophysical phenomena by the sun. It is mainly by observations of radio propagation that the evidence and elucidation are secured. Geomagnetism, aurora, and related fields, such as earth currents, also contribute. By means of the correlations with solar phenomena established by observations in these geophysical fields, the fields themselves are in turn greatly benefited, even to the point that observations of solar events permit predictions of geophysical events. In the case of radio propagation the practical benefits are so great that a world-wide observing program has been established during the past five years and is being further developed.

The ultraviolet radiation and electric particles from the sun and its corona that reach the earth's atmosphere produce ionization which varies in time and is different in different strata, depending upon chemical composition, state of dissociation, density, and temperature. This ionization and its stratification and variations are the major characteristic properties of the gaseous envelope of the earth at altitudes greater than about 40 km. above the earth's surface. A rough sketch of the atmospheric structure is shown in Figure 1. There are a number (commonly three: E, F_1, F_2) of ionized layers that reflect radio waves, and a lower layer or region (D) whose outstanding role is to absorb radio wave energy.

The ionization density and heights of these layers change with time of day, from day to day, with season, and from year to year. They are also very different at different geographical locations. The first great controlling cause of the ionosphere variations is the sun's ultraviolet light. Varying amounts of such light at different frequencies pour forth from the sun, increasing and decreasing with solar activity (roughly indicated by the sunspot number). The ionization of the several layers of the ionosphere, in consequence, varies with the sunspot number. From the ionizations and heights of the layers and from energy-absorption data are calculated the distance ranges of radio sky-wave transmission, and the upper and lower limits of frequency in which radio sky-wave transmission is possible.

Besides the ultraviolet light, the sun emits electric particles in an amount that is much less regular and more sporadic. These particles introduce variations and irregularities in the ionosphere's characteristics and in radio propagation which interfere with the more predictable trends occasioned by the general ultraviolet-light radiation. At times great outbursts of these particles produce extensive effects which, taken together, are described as an ionosphere storm. The recognition of the effects produced by an ionosphere storm upon radio propagation and the forecasting of the times of such occurrences are very important.

* Presented at the Harvard Centennial Symposium, December 30, 1946, Cambridge, Mass. This paper will be included in the Observatory Centennial Volume.

I SHALL here discuss primarily what is done to determine the characteristics of the ionosphere and something of their significance. The determination of ionosphere characteristics is essentially a radio observing program. From certain types of radio observations we obtain the characteristics of the ionosphere and their effects upon radio propagation. As these effects are in constant change, the observing program and the predictions based upon it become a great undertaking analogous to the weather observation and forecasting program. It has to be world-wide because the ionosphere characteristics vary with latitude and longitude and with geomagnetic latitude.

The nature and technique of the measurement of ionosphere characteristics by radio means have been amply described in numerous publications. They include chiefly determination of: layer height, by oscillographic measurement of time of travel of radio pulses reflected by the layer; ionization density, by observation of the upper limit of radio frequency that can be reflected; energy absorption, by recording of intensity of received radio waves. These measurements are made upon both vertically and obliquely reflected waves. Associated with these determinations, and necessary for radio propagation predictions, are measurements of radio noise, both the geophysical type, caused principally by thunderstorms, and the extraterrestrial types, stellar and solar.

We are now in the fortunate position of

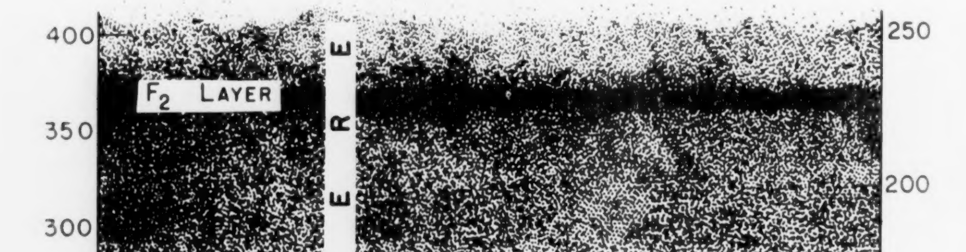


FIG. 1. STRUCTURE OF THE ATMOSPHERE

IONOSPHERE LAYER HEIGHTS AND IONIZATION ARE MERELY A SAMPLE. THEY VARY FROM HOUR TO HOUR.

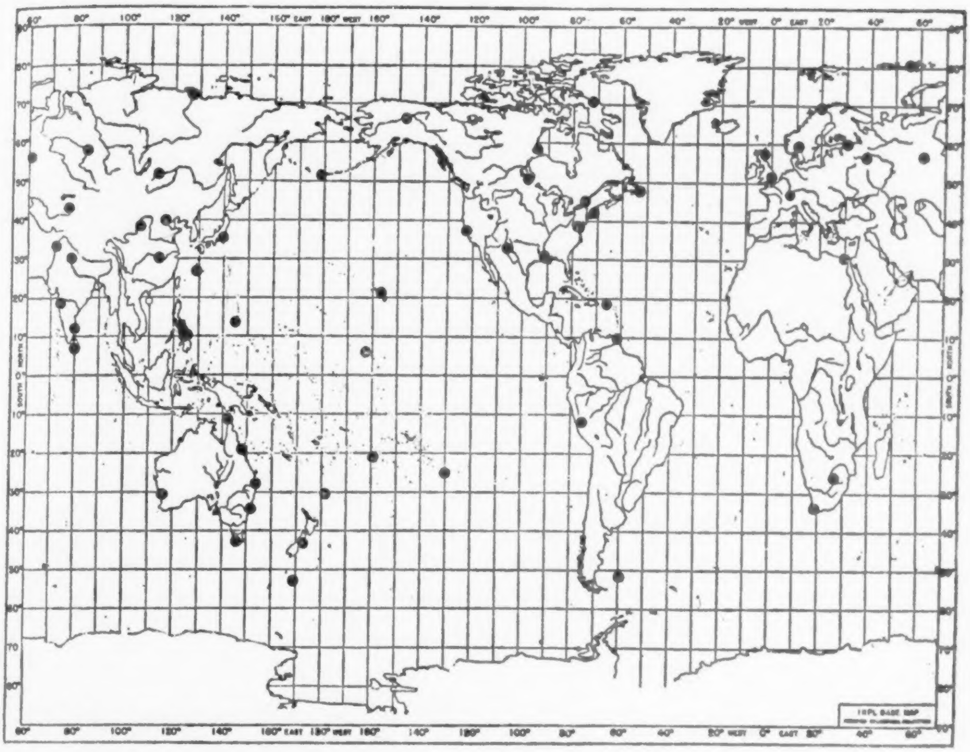


FIG 2. LOCATIONS OF IONOSPHERE OBSERVING STATIONS

having data on ionosphere characteristics for more than a full 11-year solar cycle. The compiling of such data received extraordinary impetus during the war because of the military value of precise knowledge of the usability of the various radio frequencies at specific times over specific transmission paths. Peacetime has continued and even intensified the recognition of the need for such data because of their added importance for commercial radio applications and their value in solar and geophysical sciences.

During the war laboratories were established to centralize ionospheric data for the military services, in England, the United States, Australia, the U. S. S. R., Canada, and in the enemy countries as well. The Allies cooperated in maintaining worldwide observations. By the end of the war no less than 44 stations were regularly reporting ionospheric observations. During the past year 14 have been added, so that we now have 58 stations in operation (Fig. 2). The data reported by these stations, together with analysis of radio traffic data from a number of communication networks, have permitted the continual improvement of world charts of predicted ionosphere characteristics, from the beginning in 1941, based on only three stations, to the comprehensive charts now published monthly by the Central Radio Propagation Laboratory (CRPL), National Bureau of Standards. The knowledge gained from the greatly expanded world-wide ionospheric coverage has permitted a much improved delineation of the regular variations of the ionosphere with latitude and local time.

One consequence of the improved worldwide coverage was the discovery of the longitude effect in 1943. This was the

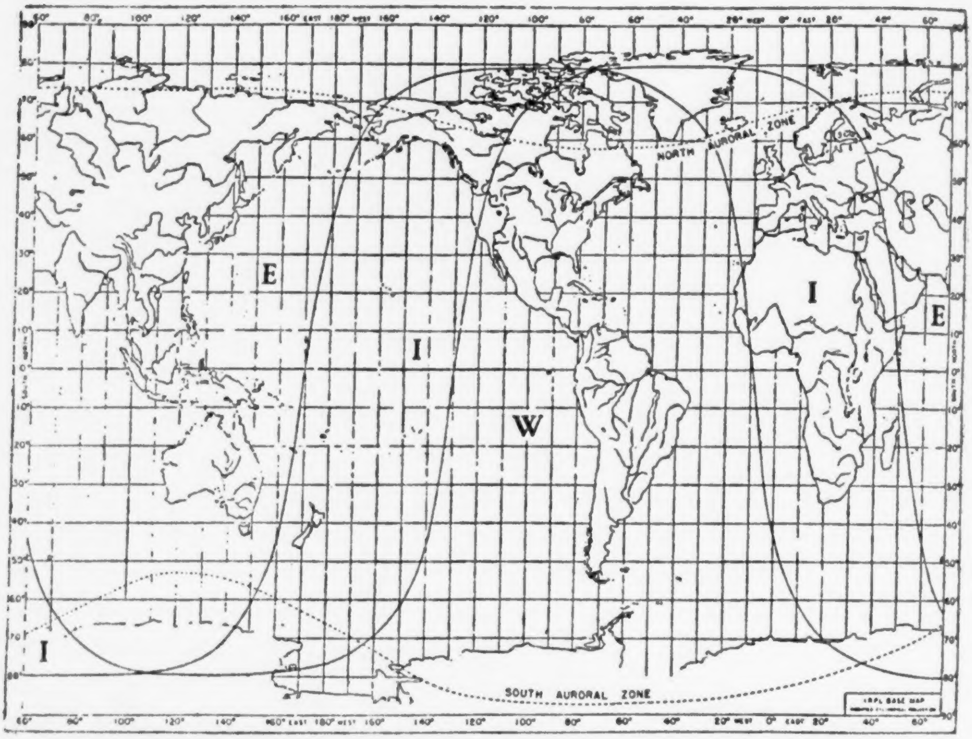


FIG 3. WORLD ZONES FOR PREDICTIONS OF RADIO PROPAGATION

THE WORLD IS ZONED BECAUSE OF LARGE VARIATIONS OF IONOSPHERE CHARACTERISTICS WITH LONGITUDE.

discovery that ionosphere characteristics are not the same, at the same local time, for stations at the same latitude but different longitudes. Instead, they depend to a great extent on the geomagnetic latitudes of the station. Thus the station at Delhi, India, shows quite different characteristics from those observed at Baton Rouge, La., at about the same geographic latitude. Following this discovery, the world was divided, for practical prediction purposes, into the three zones shown in the map (Fig. 3). In each zone the characteristics are roughly independent of longitude, to a good enough practical approximation for radio propagation predictions.

From vertical-incidence data reported from the observing stations all over the world, the CRPL prepares charts for calculation of the maximum usable frequency (muf) on any transmission path. Three sets of predicted F_2-layer ionosphere charts are prepared for each month, giving, for the three zones, the zero-distance muf and the 4,000-km. muf (see Figure 4). An E-layer and a sporadic-E muf chart are prepared, also for each month (Figure 5). From these the muf can be calculated for any transmission path anywhere in the world. The charts are published three months in advance of the month for which the predictions are made. They are in the monthly CRPL publication *Basic Radio Propagation Predictions*, obtainable from the Superintendent of Documents, Government Printing Office.

Data on ionospheric absorption, of use in calculating radio distance ranges and lowest useful high frequencies, are obtained by observation of the intensities of received radio waves. Continuous records of received intensities are made at many of the

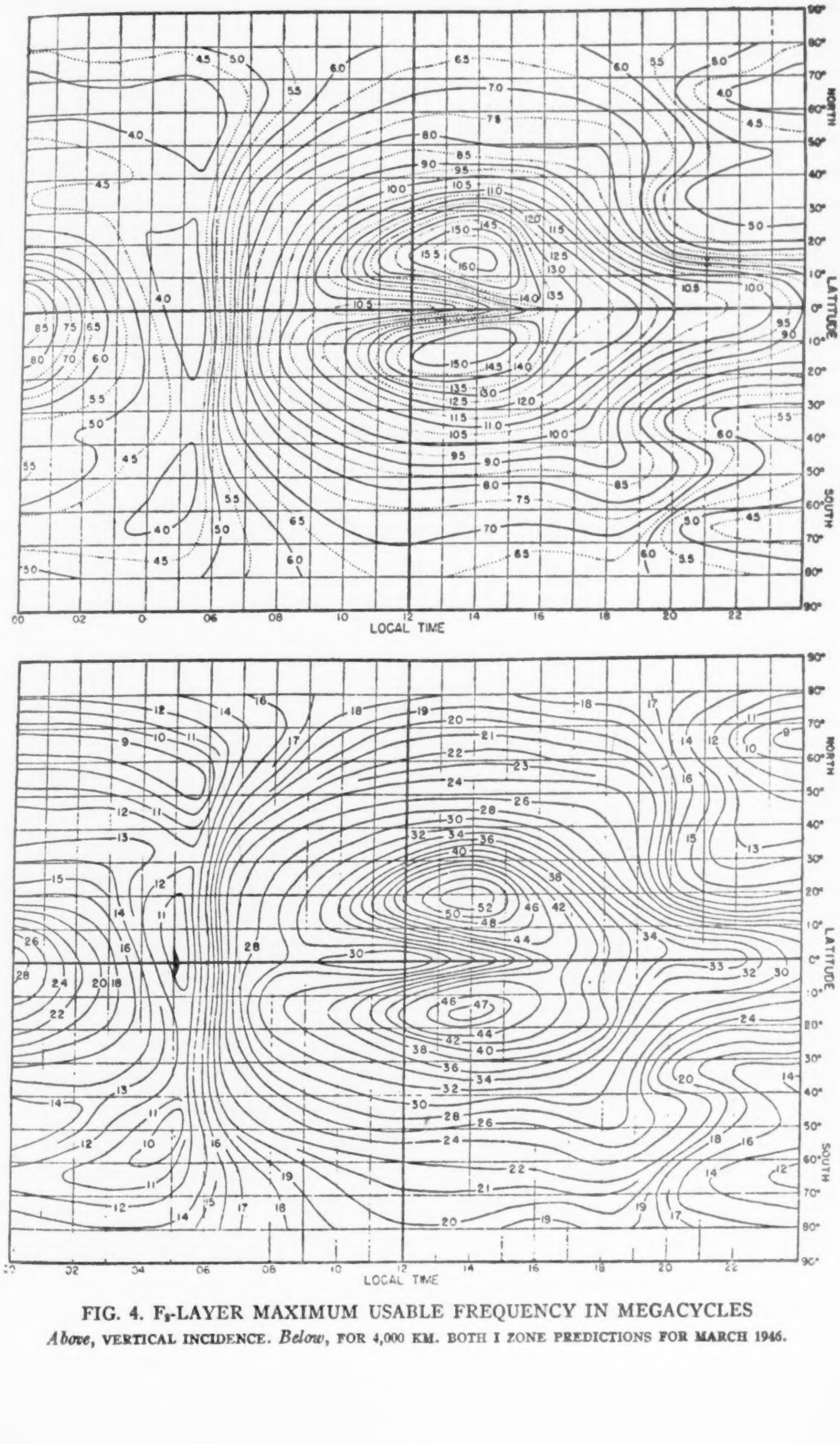


FIG. 4. F_2-LAYER MAXIMUM USABLE FREQUENCY IN MEGACYCLES
Above, VERTICAL INCIDENCE. *Below*, FOR 4,000 KM. BOTH I ZONE PREDICTIONS FOR MARCH 1946.

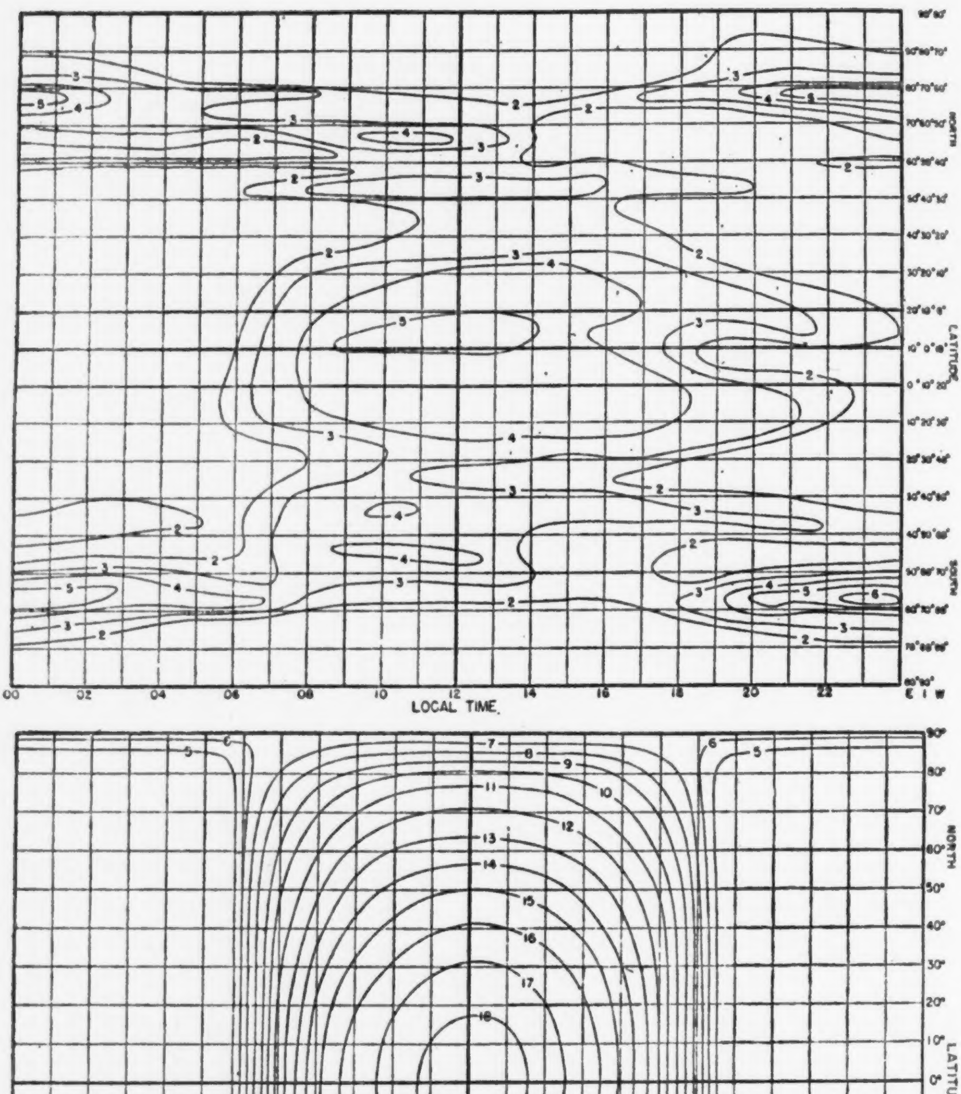


FIG. 5. MAXIMUM USABLE FREQUENCY IN MEGACYCLES

Above, SPORADIC E, VERTICAL INCIDENCE. *Below*. E-LAYER, FOR 2,000 KM. PREDICTIONS FOR MARCH 1946.

ionosphere observing stations. Figure 6 shows a sample automatic field-intensity record. Studies of oblique- and vertical-incidence ionospheric absorption based on such data have been made and continue. An equivalence theorem, similar to that used in calculating maximum usable frequencies, is used, employing the observed field-intensity data to supply numerical values to the many uncertain factors in the equation for absorption. It is found that the diurnal variation of ionospheric absorption varies, on the average, linearly with the cosine of the zenith angle of the sun, a fact that simplifies greatly the integration of ionospheric absorption over a given transmission path: the absorption can then be determined as a function of frequency, distance, and average solar zenith angle over the paths. For rapid calculation, charts of absorption index (Fig. 7) are drawn, *K* being defined as unity at the subsolar point and zero at night. Based on such a chart, calculations for actual received radio intensities for particular transmission paths are made with the aid of nomograms.

The body of absorption data, accumulated for practical use in radio operations, is being analyzed in the light of physical principles and is expected to yield important knowledge of ion collisional frequencies, mean free paths, and atmospheric temperatures and densities.

Study of absorption of radio waves propagated through the absorbing layer, which exists in daytime below the E-layer, shows close correlation with solar activity as measured by sunspot numbers. Analysis of the vertical-incidence absorption measurements by CRPL from 1944 to 1946 indicates the trend of this absorption. Preliminary estimates indicate that the coefficient of absorption increases by about 60 or 70 percent for an increase in annual average sunspot numbers from 0 to 100. It is interesting to note that this is roughly equal to the increase in amplitude of the quiet-day variations in terrestrial magnetism for corresponding increases in sunspots. This long-time trend has been recognized for some time. More recently it has been discovered that even the short-time changes in sunspot numbers affect absorption so that the sun's rotation period is reflected in the day-to-day variations in absorption. The magnitude of these short-time changes in absorption appears to be slightly less than the long-time changes,

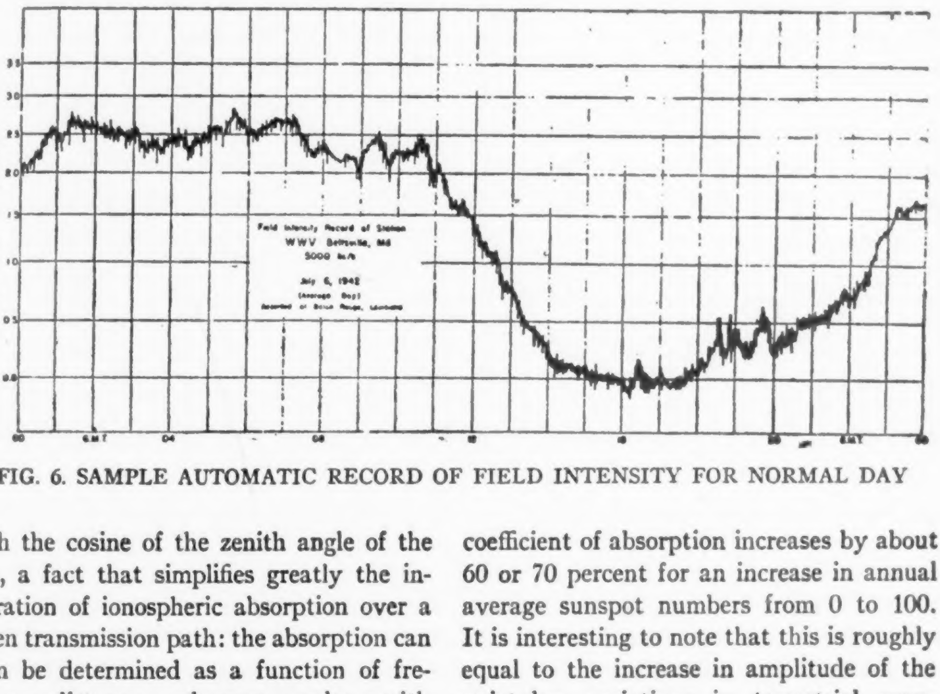


FIG. 6. SAMPLE AUTOMATIC RECORD OF FIELD INTENSITY FOR NORMAL DAY

but they are sufficiently large to have importance in communication problems. These effects are illustrated in Figure 8 by the superposed epoch method, where sunspot sequences for 13 intervals of 54 days were selected and superposed with sunspot maxima centered in the interval; absorption figures for the same 13 epochs were also superposed in an identical manner. Roughly the same characteristics appear in the absorption and in the sunspot numbers.

THE less predictable characteristics of the ionosphere, such as the stormy periods that ensue when great showers of electric particles arrive from the sun, are no less important than the more or less regular and predictable phenomena discussed in the foregoing. During periods of ionosphere storms the ionosphere is turbulent, the ionization density of the upper layers is diminished, layer heights increase, and radio communication is difficult.

There are times, too, when quantities of ultraviolet radiation vastly in excess of normal are emitted by the sun and destroy high-frequency radio transmission completely. These occurrences are great explosions on the sun and often include visible radiation so that the solar eruption can be actually seen simultaneously with the radio fade-out. The effect begins very suddenly and lasts from a few minutes to a few hours. Its consequences exist in the ionosphere throughout the earth's hemisphere illuminated by the sun. The sudden destruction of radio reception is illustrated in Figure 9; received intensity became zero simultaneously throughout the daylight half of the earth, as shown by the field intensity records; a simultaneous kink may be

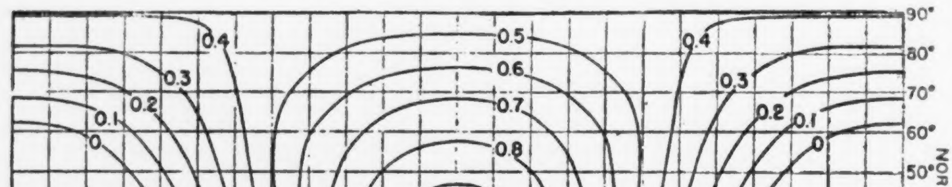


FIG 7. ABSORPTION INDEX K FOR MONTH OF MAY

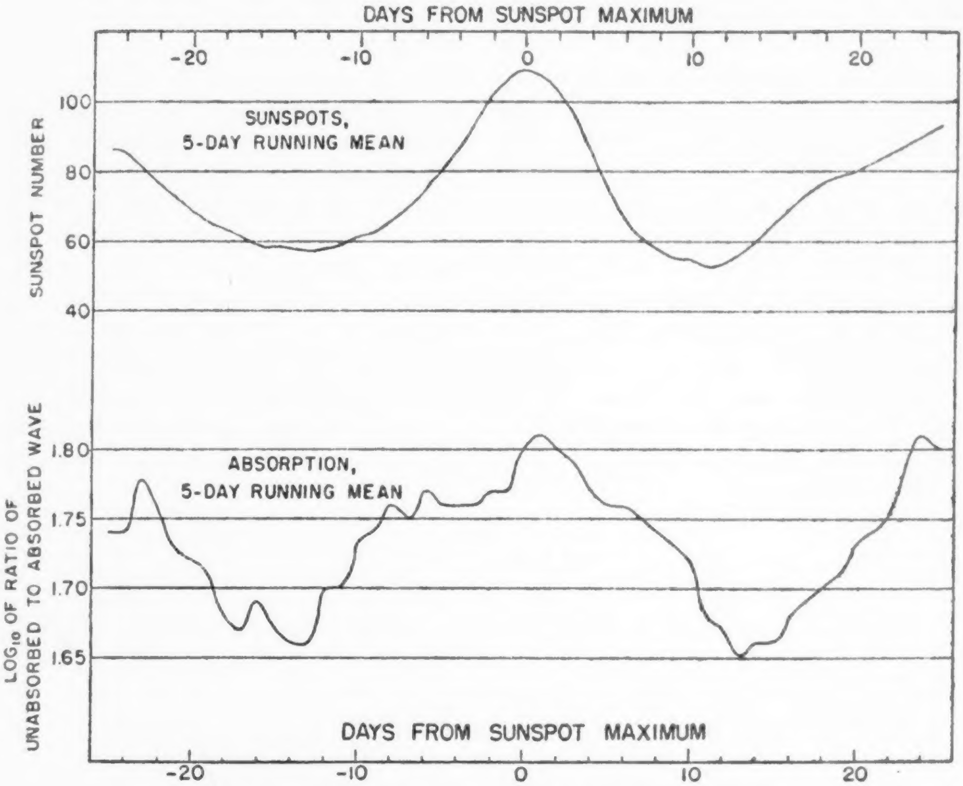


FIG 8. SUNSPOT NUMBER AND RADIO ABSORPTION

COMPARISON OF SHORT-TIME VARIATIONS (VERTICAL INCIDENCE, 2,061 KC.), 1945–46.

seen in the magnetograph records shown.

The effects of ionosphere irregularities upon radio systems of navigation are particularly serious; e.g., varying layer heights change the time of arrival of radio pulses and thus give false indications in the Loran and similar systems. Ionosphere turbulence and spotty ionization produce rapid changes in the polarization and direction of arrival of radio waves at a receiver. These effects and transmission over multiple paths produce serious errors in radio direction finders.

Ionosphere storms are so detrimental to the various radio services that the forecasting of their times of occurrence is important. The scheduling of major broadcasts is an example of the need of such forecasts. Another is long-distance flying, which depends heavily upon radio messages giving weather information, etc., and upon radio systems of navigation. Ionosphere storm effects are at a maximum in the auroral zone, and thus the very extensive radio communication and navigation across the North Atlantic are vitally affected. Here, solar observations come to the direct aid of the student of the ionosphere. A weekly forecast is issued by the Central Radio Propagation Laboratory, based in large part upon coronagraphic and other solar observations reported daily by four solar observatories, namely, McMath-Hulbert (Colorado), Harvard, Mt. Wilson, and the Naval Observatory. In these forecasts use is also made of geomagnetic and radio observations. The forecast gives a prediction of future periods in which disturb-

ances are most probable and also gives a rough estimate of the quality of radio reception, on a numerical scale, in several zones (Fig. 10). The greatest disturbance is in Zone A and the least in Zone C. The boundaries of the zones shown are coincident with geomagnetic latitude lines.

This weekly forecasting service is supplemented by a warning of radio disturbance, caused by ionosphere irregularities, a few hours to a day in advance. This is based largely upon observations of radio direction-finder bearings over the North Atlantic path. The warning service is broadcast from the National Bureau of Standards radio station WWV twice each hour (at 20 and 50 minutes past the hour).

There is another agent besides the sun that plays a part in ionizing the ionosphere, namely, meteors. When a meteor enters our atmosphere, its impact ionizes the air adjacent to it and produces an ionized trail. A meteor's passage can therefore be seen on the oscilloscope of an ionospheric recorder or a radar set. Observations of meteors by this method received extensive publicity last October because of the striking advantage of this method of observing them when clouds screen them from sight. Radio reception on frequencies above

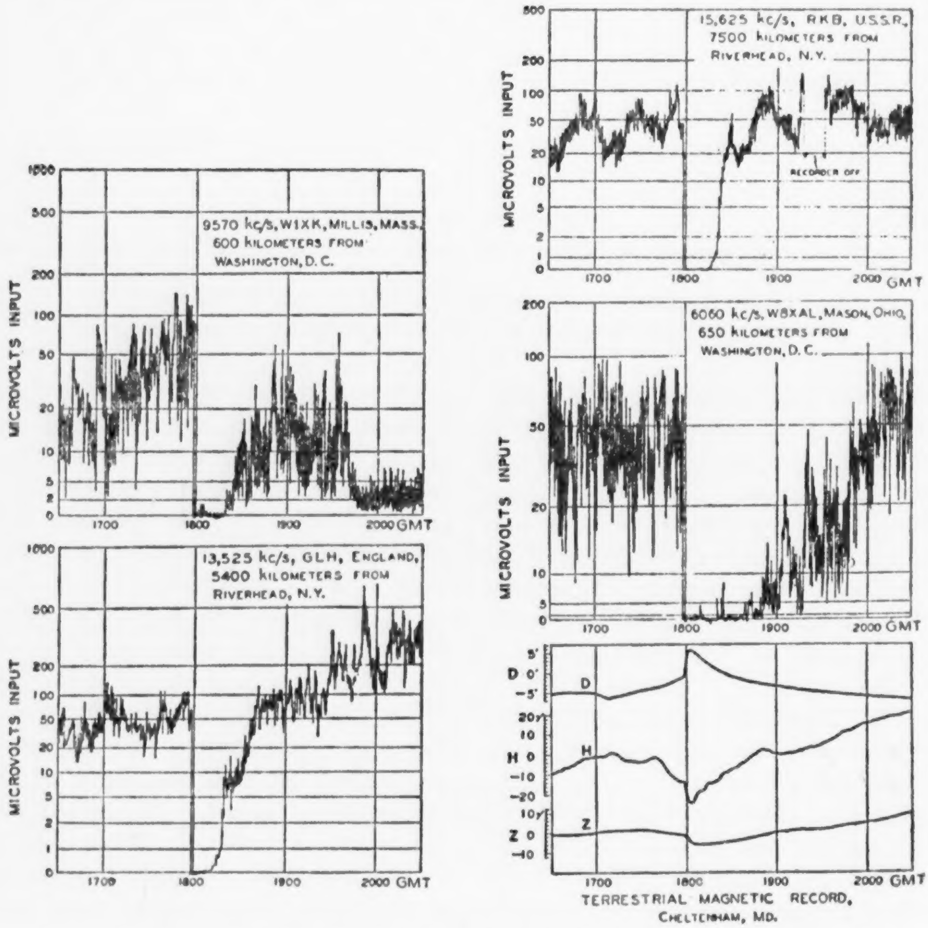


FIG. 9. SUDDEN DISTURBANCE OF THE IONOSPHERE ON MAY 28, 1936

AS REVEALED BY RADIO FADE-OUT AND TERRESTRIAL MAGNETIC PERTURBATION.

40 Mc. is sometimes subject to interference by short bursts of transmission from a very distant station, and these bursts of interference are, in some cases at least, caused by reflection from meteor trails. It is possible that the more continuous type of ionosphere ionization known as sporadic E is in large measure caused by meteors.

actual sunspot numbers. It is convenient to retain the sunspot number terminology, although the ionospheric sunspot number is much more fruitful than the actual sunspot number as a basis of comparing various phenomena affected by the sun.

Since the monthly CRPL predictions of ionospheric conditions are made five months

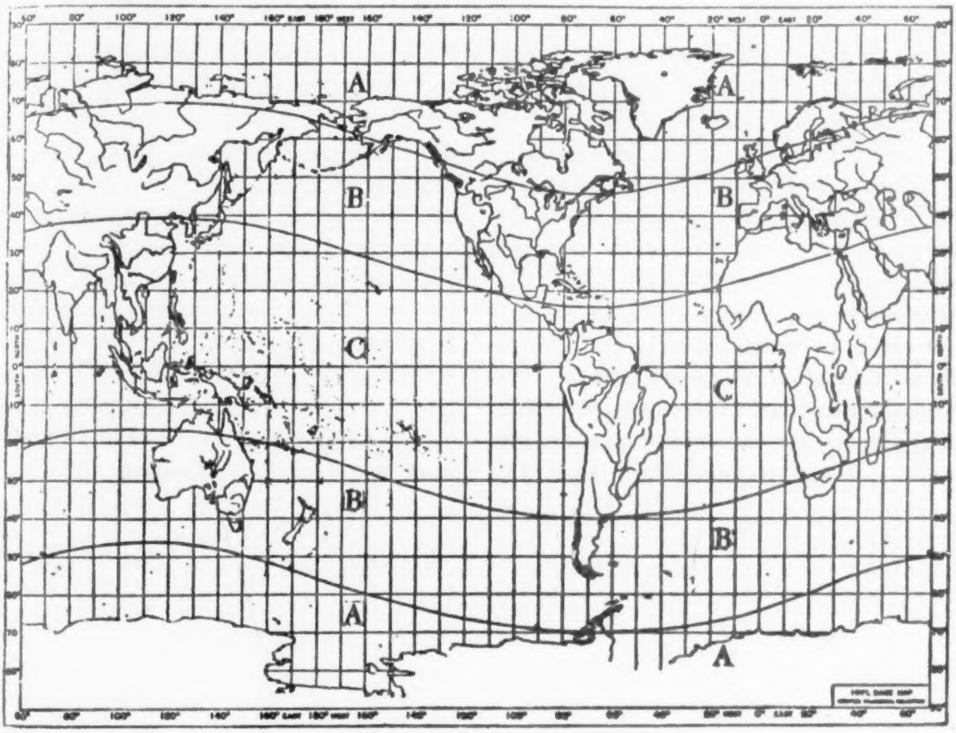


FIG. 10. WORLD ZONES FOR RADIO DISTURBANCE FORECASTS

in advance, it is necessary to estimate the probable value of the sunspot number at the time for which the predictions are made, in order to take into account the established relationship between ionospheric conditions and sunspot numbers. A simple system for forecasting sunspot numbers some months in advance has been developed at CRPL and used for this purpose. It is based on the average correlation between sunspot numbers in successive years. Predictions of sunspot numbers by this method at 3-month intervals one year in advance have had an

Reverting to the more regularly predictable ionization conditions caused by the major flow of ultraviolet radiation from the sun, the close correlation of the ionization of the ionosphere with sunspot number has been mentioned. Analysis has shown that ionospheric measurements of critical radio frequencies are a considerably better index of fundamental solar activity than sunspot numbers themselves. An equivalent, or ionospheric, "sunspot number," calculated from critical frequencies, presents a smoother and more reliable graph than

average accuracy of three (on the sunspot number scale) for six predictions during the cycle now in progress. It is unlikely that this high accuracy will be maintained, since the error limit, estimated from preceding cycles, exceeds this figure, the probable error of a prediction for one year in advance averaging slightly over seven on the sunspot number scale.

The principal emphasis to date in the study of the ionosphere has been upon practical use of the data in the forecasting of radio transmission conditions. There has not been entire neglect of the utilization of this great body of data in determining the basic properties of the atmosphere or the nature of the physical processes by which solar events control these properties. The ionosphere, the extreme outer envelope of the earth, is recognized as a strategically situated radiation laboratory. The principal laboratory tools are radio waves, recordings of geomagnetism and aurora, meteors, and, more recently, rockets. Data from this planetary laboratory will increasingly reveal the physical condition of the outer atmosphere, its temperatures, densities, mean free paths, recombination processes, geomagnetic circulation, and may also lead to information on air circulation and other phenomena in the lower atmosphere (stratosphere and troposphere). As an astronomical laboratory the ionosphere is perhaps even more interesting. The statistical studies of the regular radiations from the sun, revealed in the regular ionosphere characteristics, the observations of radio and geophysical anomalies associated with the irregular solar outpourings of radiation and particles, and stellar and solar noise measurements have taken their place alongside spectroscopic studies as powerful means of increasing the intimacy of our acquaintance with extraterrestrial events.

Despite the extensive work already under way, ionospheric and related research are only beginning; countless lines of profitable work need further cultivation.

WEALTH DIFFERENCES IN A MEXICAN VILLAGE

By OSCAR LEWIS

Dr. Lewis (Ph.D., Columbia, 1940) is Assistant Professor of Anthropology at Washington University. Prior to the war he taught at Brooklyn College and was a Research Assistant at Yale. During the war he was employed with various government agencies doing research in rural areas of the United States, Cuba, and Mexico. The material for this article was gathered under the auspices of the Inter-American Indian Institute, Mexico City. In June Dr. Lewis returned to Tepoztlán to complete his study.

ANTHROPOLOGISTS have long noted the existence of wealth differences in so-called primitive or folk societies and have recognized that there is some relationship between the distribution of wealth and the social structure. However, the absence of quantitative studies of wealth differences has impeded a fuller understanding of the role of wealth and has limited the scope and quality of our analysis of the economics of other societies. In this connection anthropologists might well learn from rural sociologists who, in their studies of rural groups in our own culture, use quantitative data on property ownership, particularly land, as a starting point in their analysis of rural society. The need for this type of data in anthropological studies has been explicitly recognized in recent years by a number of anthropologists.

I think it is worth while to consider briefly why there have been so few quantitative studies of wealth differences. One reason has been the tendency to assume that nonliterate societies are simple and homogeneous and that the study of wealth distribution would not be especially revealing. Another reason is that many anthropologists have frankly not been interested in the field of economics. But even for those anthropologists who have been aware of the need for more precise data on wealth distribution there are serious obstacles of a practical field-work nature. The sheer amount of time and work required for gathering the necessary economic data—for measuring plots of land, for determining land productivity, and for obtaining property inventories on hundreds of families—presents a discouraging if not impossible task, especially for the traditional lone anthropologist who goes into the field as a one-man expedition of all the social sciences, eager to get a bit of everything.

It is the purpose of this article to report the results of an effort to study quantitatively the wealth differences in the Mexican village of Tepoztlán and to present a scale devised to measure these differences. The data set forth here were gathered in the village of Tepoztlán over a seven-month period from December 1943 to June 1944, with the assistance of Mexican students and professional agronomists. It will be recalled that this village had been studied seventeen years earlier by Dr. Robert Redfield.

Tepoztlán is located about 18 km. from Cuernavaca on the escarpment of the Ajusco Mountain Range at an altitude of about 5,000 feet. It is a village of approximately 3,580 people (as of 1944), distributed in 853 families. The population consists of peasants, artisans, and merchants, but the village is primarily agricultural, and most of the merchants and artisans are also part-time farmers. Tepoztlán is the *cabecera*, or "seat," of the *municipio* of the same name, which consists of seven smaller villages, all within a radius of less than four miles. The country is hilly and forested, and the land is poor. Less than 25 percent of the total land area of the village is suitable for cultivation. The remainder is in forest or pasture, both of which are communally owned.

Our first step in the study of wealth differences was to determine how wealth was defined by the villagers. Invariably, *los ricos*, or "the wealthy," were described as "those who own much land and cattle." Private land ownership (in contrast to *ejido* holdings) was considered the single most important form of wealth. It is the goal of each family to own land; artisans and merchants invest in land when they can. Cattle and oxen rank next in importance as forms of wealth. In all, twelve items were most frequently mentioned by informants as forms of wealth in the village. These were *ejido* plots, privately owned land, team of oxen, plows, cattle, burros, mules, horses, hogs, sewing machines, urban property (i.e., the ownership of more than one house site and house in the village), and plum trees (*S. lutea* or a related species). Of these items we need note here only that they are all means of production and a source of income. The sale of plums, for example, is an important source of income for many families, particularly since the building of the road in 1935.

How are these items of wealth distributed among the 853 families of the village? Let us begin with land. There are three types of land tenure in Tepoztlán. First, there is privately owned land, which can be bought and sold. Second is the *ejido*, which is granted by the Departmento Agrario to the village and then by the local Ejido Commissioner to an individual family. This land can be held by the family as long as the land is being used. It can be inherited by the succeeding head of the family but cannot be sold. Third is *tlacolol*, which refers to the land on the rocky and wooded mountainsides that form part of the municipal land and which can be cleared and planted by any Tepoztecan. *Tlacolol* is not considered a form of wealth; on the contrary, it has traditionally been viewed as the last resort of the poor.

We found that 311, or 36 percent, of the 853 families own land. Two hundred sixty-seven families, or 31 percent, hold *ejido* grants. Of these, 158 families have only *ejido* grants, and 109 own their private land in addition. Thus, in a village where the ideal is for each family to own its own plot of land, we find that 64 percent of the families own no private land, and 46 percent have neither private land nor *ejido* holdings.

The size of privately owned holdings is given in Table 1.

The striking thing about the land holdings is their extremely small size. This table

TABLE 1

Size of holding	No. of owners	Percent
Less than 1 hectare	109	36.2
1–4	97	32.2
5–9	67	22.2
10–14	18	5.9
15–19	4	1.3
20–24	4	1.3
25–29	2	.66

shows that 90.6 percent of all private holdings are less than 9 hectares in size, and 68.4 percent are less than 4 hectares. The largest holding is only about 27 hectares, and there are two such cases in the village. A man with 10 or more hectares is a relatively large landholder. Over 36 percent are less than 1 hectare. *Ejido* holdings, too, are small—95 percent are less than 3 hectares in size. When we remember that 384 families own no land at all and have no *ejidos*, the essential land poverty of the villagers is revealed.

Let us now consider the ownership and distribution of cattle. Only 180, or 21 percent, of all families own cattle. Well over 50 percent of these own between 1 and 3 cows; about 40 percent own between 4 and 10 cows. The largest herd, which is owned by the wealthiest man in the village, consists of 70 head.

The distribution of two other items, namely, oxen and plows, also tells us a great deal about the agricultural economy. There are 179 families who own a team of oxen,

and 213 families own plows. Thus, of the 469 families who own land or *ejidos* or both, over 63 percent own no oxen with which to work their land, and 52 percent own no plow. The families who own oxen therefore do a great deal of custom work, from which they realize a good income.

In order to rank the families according to their wealth, we devised a point scale using one point for every 100 pesos of value. Points were assigned to each of the items in accordance with the approximate sale value or the approximate production value or both. Thus, one hectare (approximately 2.4 acres) of *ejido* land was assigned 3.6 points because the average annual production of one hectare of *ejido* land in Tepoztlán as of June 1944 had a market value of 360 pesos. On the other hand, one hectare of privately owned land was assigned 7.2 points, which represented both the value of production and the sale value.

We were tempted to assign points for prestige value, such as in the case of privately owned versus *ejido* land, but to avoid further complications this was not done.

The items of the scale and the assigned points for each item are given in Table 2.

TABLE 2

1 hectare *ejido*	3.6
1 hectare private land	7.2
1 team of oxen	7.2
1 plow	0.7
1 cow	3.1
1 donkey	1.5
1 mule	3.0
1 horse	2.5
1 hog	1.5
1 sewing machine	3.5
urban site & house	7.5
1 plum tree	1.0
nonfarm occupation	1.0 for every 100 pesos earned annually

A score was obtained for a given family by adding the number of points which it obtained for each item. For example, if a family owned 4 hectares of land (the minimum size of holding considered necessary by Tepoztecans for a "decent living" for a family of five), 1 plow, 1 team of oxen, 1 horse, 1 cow, 2 hogs, 2 plum trees, and a sewing machine, it would receive a score of 47 points. Since this is a very modest list, even according to Tepoztecan standards, a score of 40 to 50 points may be taken to represent approximately the minimum in property ownership necessary for a self-sufficient farm family. The distribution of scores is presented in Table 3.

The most significant features in this frequency distribution are (1) the extremely

TABLE 3

FREQUENCY DISTRIBUTION OF 853 FAMILIES ON ECONOMIC POINT SCALE

Score	No. of families	Percent of total	Subgroup	Percent of total	Large group	Percent of total
400–407.4	1	0.11				
220–253.0	3	0.35				
200–219	2	0.23				
190–199	1	0.11	B	1.5		
180–189	1	0.11				
170–179	3	0.35				
160–169	2	0.23			III	4.4
150–159	3	0.35				
140–149	3	0.35				
130–139	5	0.58	A	2.9		
120–129	4	0.46				
110–119	4	0.46				
100–109	6	0.70				
90– 99	16	1.87				
80– 89	18	2.11				
70– 79	17	1.99		13.9	II	13.9
60– 69	20	2.34				
50– 59	28	3.28				
40– 49	20	2.34				
30– 39	74	8.67	B	21.6		
20– 29	111	13.00				
10– 19	206	24.15			I	81.5
1– 9	213	24.02	A	59.9		
0	92	10.78				

wide range of wealth differences from zero to over 400 points; (2) the great majority clustering around the lower end of the scale,

indicating widespread poverty (note that 81 percent of the families have scores below what we have tentatively designated as a minimum for decent subsistence); (3) the 92 families having a zero score, and (4) the manner in which, from the distribution of the scores, the families fall into distinct economic groups. Eighty-one percent of the families are in the lowest group (point score 0–39); 13.9 percent are in the middle group (40–99); and 4.4 percent are in the upper group (100–407.4). The lowest group can be broken down into two subgroups, from 0–19 and 20–39, which we shall call I-A and I-B, respectively. The middle group will be referred to as Group II, and the upper group as III-A (100–159) and III-B (160 and over).

To test the validity of our groupings we asked ten informants to name the ten wealthiest families in the village. All those named were in our top group. Another way in which we checked our scale was to present names selected from each of the economic levels of the scale and ask informants to rank them according to their wealth. Again we found a very high correlation.

WHAT are the characteristics of each of these economic groups? First let us consider the families with zero scores. For the most part they are either young married men, most of whom live with their parents, who also have low scores; or they are widows or old men, many of whom live alone. One-third of this group are women, who manage to earn a living by small-scale trade and by doing odd jobs.

Group I-A, which consists of 511 families with scores from zero to 19, contains 97 percent of the landless people in the village. Three hundred fifty-four, or 70 percent, of the families in this group have zero score for land. How do these landless people live? Approximately one-third depend upon *tlacolol*, but all depend upon a variety of activities which together provide only a meager income. Thus, many burn charcoal, sell wood, work as peons, are small traders, or have some other part-time occupation. They have some measure of security in that most of them own their houses and house sites or will inherit them. About one-fourth of them plant some corn around their houses and about 40 percent have some income from plum trees. About one-third have hogs. Less than one-third own a mule, horse, or donkey, which are so essential for work and transportation.

The families in Group II include most of the artisans and merchants as well as better-to-do farmers. The former are the most acculturated group in the village. They are the ones who wear store clothes, who send their children out of Tepoztlán to high school, and who generally have a higher standard of living.

Group III consists of 38 families, all of whom have high scores on land or cattle or both. About one-half of these families have inherited their land from wealthy relatives who before the revolution were *caciques* and dominated the village. The other half have worked their way up to their present position.

One might ask whether there is any relationship between position on this scale and standard of living. Do the wealthiest people have the highest standard of living? This cannot be answered categorically. On the whole, the people in Group III consume more meat, milk, eggs, and bread, and they generally live in better-constructed and better-furnished houses, some of which have running water. However, they are not the ones who go in for modern dress or any ostentatious spending for comforts or luxuries. They are a hard-working people and not a leisure class. One of the distinguishing characteristics of this group is that they generally have hired men all year around, but, with the exception of two men, they work side by side with their peons.

What is the relationship between

wealth and the adoption of new traits? The Mexican census of 1940 included three interesting items which provide us with some data on acculturation in relation to standard of living. The questions were: Do you eat bread (as against *tortillas*)? Do you wear shoes (or go barefoot or wear huaraches)? Do you sleep on a bed or a cot (or sleep on the ground or on a *tepexco*—a raised frame upon which the *petate* is placed)?

From a special tabulation of the census of Tepoztlán, we were able to correlate the responses to these questions with the family position on the economic scale. The results are shown in Table 4.

It is clear that eating bread correlates positively with economic position. Thus 23 percent of the people in Group I-A as compared with 57 percent of the people in Group III-B ate bread. Furthermore, we know from our observation that the wealthier people eat bread more often and in greater quantities. The point is that bread is still a luxury item in this village.

Wearing shoes and sleeping in beds do not correlate with wealth, but rather with age.

TABLE 4

Group	Percent who eat bread	Percent who wear shoes	Percent who sleep on bed or cot
I-A	23.20	6.46	14.12
I-B	32.30	6.78	23.18
II	50.82	12.06	30.71
III-A	41.55	7.14	21.42
III-B	57.69	5.12	16.66
Tepoztlán as a whole	31.18	7.41	19.29

That is, the older people, whether rich or poor, prefer to use huaraches or go barefoot and to sleep on the traditional *petate* or on a raised *tepexco*. We have here a nice example of the factor of selectivity in the adoption of new traits. Families who do not use shoes or beds will often buy sewing machines. For example, whereas only 6 percent of Group III use shoes, 70 percent own sewing machines.

It should be noted that a larger percentage of the middle group—Group II—have adopted new traits, even though their economic resources are less than those of Group III.

There remains only for us to discuss the age factor in relation to position on this scale. Table 5 shows the frequency distribution of the age of heads of families by economic categories.

TABLE 5

AGE DISTRIBUTION OF HEADS OF FAMILIES BY ECONOMIC GROUP

Group	Below 29 yrs.	30–49 yrs.	50–69 yrs.	70–99 yrs.	Total
0	31	31	18	12	92
I-A	63	194	132	30	419
I-B	6	88	77	14	185
II	3	46	52	18	119
III-A	0	9	15	1	25
III-B	0	1	11	1	13
Total	103	369	305	76	853

It is apparent that there are no younger people in the upper group and very few in the middle group. The bulk of the younger people are at the low end of the scale. Conversely, the wealthiest are of an advanced age, mostly between fifty and sixty-nine years of age. Forty-one percent of the heads of families over age fifty are in Group I; 59 percent are in Group II; and 74 percent are in Group III. But while there is a positive correlation between wealth and old age, the converse is not true. The fact that 41 percent of the older people are in Group I shows that vertical mobility is quite limited. The practice of not dividing up the property until the death of the parents often results in adult married sons with as many as five children being entirely landless and without a house.

Our point scale, although not a refined statistical instrument, has revealed a much

wider range and a less equal distribution of wealth than one might anticipate for a community of this type. With this scale we can determine the relative economic status of every family in the village. We are therefore in a position to study such things as leadership, marriage, the *compadre* system, and standard of living in relation to economic status. We believe that if a similar scale were used in studies of other societies, adapted to local conditions as necessary, we should have a much better basis for comparative analysis of the role and distribution of wealth.

THE SHELL

In my hands are the lives of millions—
Never forget that;
O you who hug the earth beneath my whisper
In the stark night,
Know that I am pain and death,
Madness and fear unending;
You who shudder in the hollows,
In the dugouts, the foxholes, and under cliffs of earth,
Remember me:
I will find you out . . .
And all the bright hopes of man,
The memories, desires, plans, the thousands of words—
Will fade in my whisper
That grows to a shout,
That crashes and overthrows
Man's world.

DANIEL SMYTHE

X-RAYING THE PERSONALITY: AN INTERPRETATIVE EVALUATION OF TWO PROJECTION TECHNIQUES

By LOUIS WEKSTEIN

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FOR many years the clinical psychologist has gazed with undisguised awe and envy at that highly prized instrument of the physician, the X-ray. True, the psychologist did have at his disposal a number of instruments for arriving at a diagnosis of the personality, but these techniques lacked the well-defined clearness, the depth, that is associated with the all-powerful X ray.

Intelligence tests such as the Stanford-Binet, and especially the Wechsler-Bellevue, can yield fruitful information about the personality structure in addition to the intellectual status—the I.Q. score—when they are administered and interpreted by a competent psychologist. Personality inventories, aptitude tests, association tests, and interviews serve to supplement the data secured from intelligence tests.

Nevertheless, the thoughtful psychologist occupied with diagnosis has felt, and rightly so, that none of the above methods gives a clear, integrated picture of the total personality, that none of the above techniques is sufficiently penetrating, either individually or collectively, to take into account the numerous factors involved in the subject's mode of perceiving.

The central core of the perceptual process is meaning, and it is vital for the psychologist to ascertain the individual's meanings, his way of seeing life, his modes of reacting to reality, his emotional life, and the strength of his drives and needs.

In short, it is the purpose of the psychologist to study and evaluate the dynamic interplay of forces operating in the individual. Moreover, he must accomplish this purpose in the shortest possible period of time. The average person who presents himself for personality evaluation for one reason or another has neither the time nor the financial resources for extended observation. Also, the time the psychologist is able to spend with each subject is limited.

Unfortunately, the standardized tests mentioned do not meet the above requirements. It has been found only too often, after spending two to three hours administering intelligence tests, personality inventories, and aptitude tests, that relatively little truly significant material has been revealed about the subject.

For example, the tests may reveal that the subject is superior in intelligence; that his reasoning and language ability are good; that his rote and logical memory are on a high level; that he is more successful on verbal than performance portions of the scale; that he is extroverted, inclined to be ascendant, cooperative and pleasant in his manner and speech; and that he has many theoretical interests. Despite this description, we know precious little about this subject. He might be a happily married, kind, and moderately successful businessman, he might be a university professor of chemistry, an avid reader of THE SCIENTIFIC MONTHLY, or he might be a maladjusted and dangerous killer.

Only by eliciting a more comprehensive imprint, only by the inclusion of a greater number of facets and nuances of the personality structure, can our subject with the superior intelligence be understood as a

living, adjusting, striving, reacting organism.

During the past two decades, psychologists have been turning in increasing numbers to research toward just such an end, and a number of tests designated as projection techniques have come into use. Some of these tests have been so effective in yielding fruitful clinical data and so valuable in revealing the inner structure of the personality that they might well be referred to as X-ray techniques. Today every mental institution, guidance center, and clinic worthy of the name makes use of these tests. Schools, colleges, the armed forces, and numerous progressive organizations that find it necessary to evaluate personalities have followed suit.

Projective methods of examination are quite unique. The subject is confronted with an unstructured test situation. The term "unstructured" refers to the fact that the materials utilized in the test situation and their relationship are not strictly defined.

The subject is instructed to follow his own inclinations in responding to the stimulus material. He is thus free to handle and to interpret the situation in any way that he wishes. He is free to organize the material as it would please him. There is no "right" answer. No two subjects organize the test material in precisely the same manner because there are no two identical personalities. Each subject projects his own individual picture, his own individual X-ray.

It is both interesting and instructive to contrast projection methods with those followed in intelligence tests. In the intelligence test the subject is given little or no leeway. He is expected to react to the stimulus material in one way—the prescribed, correct way. The test situation is thus structured. The standardized tests, as L. K. Frank points out, rate the individual in terms of how nearly he approximates to the acceptance and use of culturally described patterns of belief, action, and speech.

The projection techniques, on the other hand, offer the subject a plastic medium, a film, so to speak, on which he can project his mode of perceiving, his meanings and feelings. The imprint that the subject leaves on this film is an X-ray which the psychologist can interpret.

This discussion will be limited to a descriptive evaluation of two of the most valuable projection techniques in general use today, the Rorschach Ink-blot Test and the Thematic Apperception Test.

THE Rorschach test takes it name from its creator, Hermann Rorschach, a brilliant Swiss psychiatrist and research scientist. The test was the result of ten years of experimentation on his part. The stimulus material of this diagnostic procedure—the "film"—consists of ten ink blots that were selected from thousands of trial blots. In five of the blots, colored ink is used in addition to black ink.

These ink-blot cards were originally published as part of *Psychodiagnostics*, Rorschach's monumental contribution to psychology. Rorschach considered *Psychodiagnostics* as merely a preliminary outline of his thesis. Unfortunately, his premature death at the age of thirty-seven interrupted his amazing researches. His colleagues in every part of the world, however, continued his work, amplifying it and filling in gaps.

Dr. Nolan D. C. Lewis, Director of the New York State Psychiatric Institute, writes as follows in a brief preface to Klopfer and Kelley's *The Rorschach Technique:*

> The Rorschach method is remarkably effective in estimating the intellectual status of an individual; in revealing the richness or poverty of his psychic experience; in making known his present mood, and in showing the extent of his intuitive ability as well as in disclosing his special talents and aptitudes. By virtue of its unique function in these areas, the value of the technique is becoming increasingly clear to psychologists in social service work, personnel administration and vocational guidance.
>
> In psychiatry, the validity of the method as a diagnostic instrument has been established. It

points the way to new understanding of mental disorders and it has gained a reputation for its service in identifying borderline cases and in differentiating among psychoses, neuroses and organic brain disorders. Because the method differentiates reliably between normal groups with varying personality traits and subjects with mental disorders, it is finding a use in the U.S., Canadian, British and German armed forces for the detection of the unfit. Here as elsewhere it detects anxieties, phobias and sex disturbances, as well as more severe disorders and serves as a guide for appropriate treatment. . . .The limits of the research possibilities of the Rorschach method are not yet in sight.

The test is administered in the following manner: The subject is comfortably seated at a table or desk with the psychologist seated a bit behind. This arrangement makes the subject less aware of the psychologist, who is to be a witness to these projections. It should be mentioned that in certain cases, however, it is necessary to face the subject to secure the best results.

As the next step in administration, some psychologists simply hand the subject the first ink blot and ask, "What do you see here?"

Whether this direct technique should be followed or whether a few words of explanation are in order again depends on the subject. A curious or an insecure, inhibited person may require encouragement as well as explanation. I have found that resistance can be easily overcome in such subjects by the use of a short preface such as this:

You've probably played with ink blots as a child. You drop ink on a paper and then you fold the paper and squeeze. That's how this test was constructed. The blots were specially chosen from thousands of trials. Now I'm going to have you look at ten such blots one by one and I want you to tell me what you see, what each blot means to you. There is no right or wrong, so you can feel perfectly at ease. This will give me a good idea of your imagination.

Even if no reference to imagination is made, subjects invariably regard the test as an investigation of fantasy. As Rorschach has pointed out, this does not affect the outcome of the test. Those subjects who are not imaginative cannot become imaginative because they believe the test to be one of fantasy. Those who are imaginative prove it. Actually, the interpretation of the ink-blot configurations falls in the field of perception rather than imagination: therefore, whether the individual be imaginative or be lacking in imagination means little, and those subjects who may be lacking in fantasy reveal the inner structure of their personalities just as clearly through their projections—through their perceiving powers—as those with a rich fantasy life.

The Rorschach test is unquestionably the most complicated test in the field of clinical psychology. To the layman and the novice, scoring elements appear particularly involved and confusing. Actually the administration of the test takes between thirty minutes to an hour in most cases. The interpretation of the data, of the "X-ray," may require a full day's concentration. Obviously, the Rorschach interpreter must be extremely well versed in psychopathology.

The psychologist, after handing the ink-blot card to the subject, notes the time required for the subject to give the first response to each card. How long it takes the subject to give his first response is quite significant in that his reaction time to cards with color and shading can be compared with those cards that are achromatic and have little shading.

Every response that the subject gives to the ten cards is carefully recorded. Few responses, many responses, or failure to respond to one or more of the cards is of diagnostic significance.

Psychoneurotics present different patterns of responses than schizophrenics or normals. Extroverted people respond quite differently than rigidly repressed introverts. For example, one subject may describe Card I as a huge bat, another may notice a veiled human figure where the first saw the body of the bat, and to a third subject the card may represent two Teutonic knights about to swoop

down on a knave with upraised hands. How are such responses evaluated and differentiated from one another? What diagnostic significance can be attached to the incidence of a particular type of response?

Three categories operate in analyzing a response: the location, the content, and the determinant. Every scorable response must have a location, a content, and a determinant. The relationship of the various categories is carefully studied, and their ratio is represented mathematically. The location and content of the response are relatively easy to ascertain, although the determinant may prove more difficult. These categories will be considered in their order.

The location refers to that portion of the ink blot that the subject has selected for his interpretation. Letters of the alphabet have been designated to symbolize the type of location response. If a subject uses the entire blot, it is scored as a whole response, *W*. If a large or frequently seen, obvious portion is selected, it is scored as a detail response, *D*. If a small, unusual, or rarely seen portion of the blot is chosen for the answer, it is scored *Dd*. If the subject chooses a white space rather than black or colored portions of the blot, the response is scored for space, *S*.

The absolute number of *W*, *D*, *Dd*, and *S* is not so important as their ratio to one another. *W* represents the tendency to organize and involves integrative ability. Subjects who are intelligent are able to produce more than seven good *W*'s. The feebleminded give few *W* responses, as do subjects who suffer from mental deterioration. *W* then is an indication of the theoretical, of the abstract, the original, and the creative tendencies. Many *W*'s are found in the protocols of talented subjects. It should be noted that there can be poor *W*'s—*W*'s poorly perceived. Confabulated *W*'s may indicate mental illness. The good *W* must have clearly perceived form accompaniment.

The *D* responses are most frequent. They represent the common-sense, realistic element and are a sign of practicality. People who give a preponderance of *D*'s (in relation to *W*'s and *Dd*'s) are reproductive rather than productive. They are down-to-earth people who see the obvious and are not particularly concerned with theory.

Preoccupation with rare, unusual details—the *Dd*'s—speaks for itself. Such subjects are very meticulous and precise. They are absorbed by the minute. In the extreme, such a person would be a faultfinder, a nagger, a precisionist.

S responses indicate oppositional tendencies. These tendencies may be expressed against the milieu or directed to the self. This negativism may be emotional or intellectual. Other factors in the test must be considered before the *S* response can be truly evaluated.

Rorschach considered a distribution of approximately 25 percent *W*'s to 65 percent *D*'s to 10 percent *Dd*'s and *S*'s as optimal. However, it must be emphasized from the gestalt point of view that all the factors involved must be considered in relation to one another. The parts cannot be divorced from the whole, and there are many exceptions to this optimal distribution.

It is obvious, then, that a well-adapted, intelligent person will give a good ratio of *W*, *D*, and *Dd* responses. An individual with a huge preponderance of *W*'s, with few *D*'s and *Dd*'s, would be the highly abstract, theoretical type, very impractical, and uninterested in anything detailed. The university professor is often caricatured as such a type.

In the schizophrenic personality there is frequently an emphasis on *W* and *Dd*. These people do not see the obvious and they are ill.

An overweight of *D* and *Dd*, on the other hand, although not pathological, indicates the very practical realist who runs away from theory. Although this may be quite

desirable in certain occupations, such people find liberal arts courses (especially in philosophy) incomprehensible.

Every response must be scored for content in addition to location. Subjects frequently see animals, human figures, objects, plants, anatomical content, landscape, geological content, and clouds in the blots.

The average subject gives between 35-50 percent animal responses. Less intelligent people with more stereotypy show a higher percentage of animal responses. Very imaginative individuals give less than 35 percent animal responses. Young children and older people tend to show high animal percentage. The young and the old are more stereotyped.

Human responses connote an interest in fellow beings. Subjects who give more human parts than complete figures are interested in their fellows, but it is an anxious preoccupation. Many anatomical responses from an individual who is not a physician (and even in the cases of some physicians) indicate hypochondriasis.

The third category for which each response is scored is the determinant. In searching for the determinant, the psychologist seeks to ascertain what prompted the subject to elaborate on a specific blot or portion of a blot. What prompted the subject to attach significance to this or that part? Four main areas operate here: form, movement, color, and shading.

The form, that is, the shape of the blot area, may determine the response. For example, the subject may give the bat response to Card V, then point spontaneously and outline the head and body and wings of the bat. Such an answer has clearly been determined by the form of the ink blot.

The problem of the psychologist in scoring is to decide whether the form is accurate or inaccurate. Both Rorschach and Beck feel that if enough subjects see a particular design, it is good form (*F* plus), on a statistical basis. If the psychologist is in doubt about the accuracy, he may ask the subject to elaborate and clarify the response in the inquiry that is held subsequent to the administration of the test.

It has been found that form is related to emotional control. The higher the *F* plus percentage, the better is the subject's control over his emotions. The subject with 100 percent *F* plus has too great a control over his emotions. He permits them no expression. In this group we find the overrational person, the pedant, the restrained, the inhibited person, the individual who is afraid to permit his feelings any outlet. Depressed patients frequently indicate their repression and self-restriction by such high *F* plus percentage. In a number of cases, brain diseases may be responsible for such restriction. The optimal percentage for normal subjects has been found to be 80–90 percent *F* plus.

The percentage of good form responses has also been found to correlate with intelligence. (It should be noted that the intelligence level is not solely determined by form percentage, for the number and quality of *W* responses already discussed, movement responses, original responses, and a variety of other factors are contributory.) It has been found, however, that subjects below 70 percent *F* plus are intellectually inferior. Morons, imbeciles, paretics, and senile dements fall in the 0–60 percent *F* plus level.

Movement can also be the determinant of a response. A response is scored *M* if in addition to form perception there is also a kinesthetic element present. The movement must play a primary role, and an actual sensation of motion must be there. For example, in Card III, the response "Two gentlemen bowing to one another" is a movement (*M*) response. Frequently inquiry is necessary to determine whether the response should be scored for movement or for form.

Movement responses of humans in action

are definitely related to mental productivity and creativity. Mature, creative people of good intellectual endowment give five or more *M*'s. Movement, then, is one of the signs of intelligence and indicates a reactiveness to inner stimuli.

Since the *M* responses are a sign of rich inner life and the *W*'s are an indication of mental ability and also intellectual ambition, it is extremely interesting and important to study the relationship of *W* to *M* in the protocol. This ratio enables the psychologist to assay the degree of success that the subject has in adjusting intellectually. For example, if there are three or four times as many *W*'s as *M*'s, the subject does not show sufficient reactiveness to inner stimuli to account for his intellectual ambitions. On the other hand, an emphasis of *M*'s over *W*'s would indicate that the subject does have the endowment but is not utilizing his rich inner life to best advantage. Klopfer feels that at least five *M*'s and approximately twice as many *W*'s are optimal.

Feeble-minded people, schizophrenics, and senile dements and other deteriorated patients generally give no *M*'s. At best such people cannot give more than one or two *M*'s. (*M* is also scored plus or minus depending on how well the form of the movement is seen.)

A third possible determinant of a response is color. Color may be the primary determinant or it may appear with, and in harmony with, form.

Color responses are representations of the affective part of the subject's personality. Just as the form (*F*) answers denote the degree of restriction and inhibition, so the color answers denote the degree of emotionality. Obviously, in the well-adapted, well-socialized person there must be a balance between form and color.

Three main types of color responses have been differentiated. The first of these is color naming without form and is designated *C*; i.e.: "That's blue and that's red;" "Blood;" "Sky." This type of answer is pathological. It is never given by normal subjects. *C* answers are given by impulsive, explosive, emotionally uneven and unpredictable people.

Responses where the color is the primary determinant and the form is secondary are termed *CF*'s. Thus, in these answers the form of the blot is not disregarded; i.e., "Sunset," to Card IX.

Responses where the form is primary but the color plays a significant part in the concept are termed *FC*; i.e., "Caterpillars," for the green figures in Card X.

The greater the emphasis of *FC* over *CF*, the better adjusted, the more socialized, is the subject. Obviously, the well-integrated individual has a good control over his emotions. Responses of the *CF* variety are common for normals and only give cause for alarm when they are not balanced by a sufficient number of *FC*'s.

It is rather interesting to note that neurotic subjects show color shock, that is, they are affected by the chromatic cards. Color shock is measured by such criteria as annoyance, confusion, increased reaction time, and a number of other signs manifested in handling the colored cards. At least three criteria should be present before a diagnosis of color shock can be made.

A short time prior to his death, Rorschach discovered a fourth determinant, shading. Every card has shading elements present to a greater or lesser degree. These shading nuances, called chiaroscuro, may influence the subject in the formation of his concept. A chiaroscuro determinant is designated as *Ch*. Again, as with color, three types of *Ch* responses have been differentiated.

A pure *Ch* response is a definite indication of uncontrolled anxiety. In the *ChF* response the shading determines the answer and the form is secondary. Such responses signify general insecurity or anxiety of which the subject is unaware.

In the *FCh* type of response the subject has been primarily influenced by the form, but the shading has played a part. Such subjects are introversive, cautious, and given to introspection and self-analysis. More than three *FCh* is a sign of self-preoccupation. Shading, then, is an anxiety characteristic which may be tempered by form.

The responses are also scored for popularity and originality. Original responses are very rare—one out of a hundred. Only intelligent subjects give good *O* pluses (which stand for originality). In attempting to evaluate the subject's ingenuity and intellectual status, the percentage of *O* responses is considered an important factor.

Popular responses are those given by many subjects. They are a sign of participation, of common sense. The normal subject gives a number of them. However, just as too many original responses would place a subject apart from this world, too many popular responses would signify that he is commonplace—that he is dull and boring.

After the subject has responded to all ten cards, the psychologist may question him about his answers to specific blot areas. This inquiry may determine whether a particular response should be scored for movement or for form, whether color is primary or secondary, whether shading is primary to form, etc.

The next step is tabulating each response in the three main categories. Thus, the response "Two knights sweeping down on a knave" would be scored *W M H*: *W* because the entire blot is used; *M* because there is human action plus form; and *H* because the content is human.

After each response has been treated in this manner the *W*, *D*, *Dd* and S, *F*, *M*, *C*, etc., answers are added up and their percentages of the total are obtained.

It must be stressed that no one response will determine the diagnosis of the personality. The Rorschach expert studies the relationship of the responses to one another in the total scheme. He is interested in the configuration. The parts in themselves are misleading and frequently meaningless. As the gestaltists put it, the whole is more than mere random parts. It is an integrated cohesive totality. It is this dynamic structure that the psychologist seeks to assay.

Just as the physician is frequently called upon to reassure a patient who manifests a symptom of disease after an evaluation of his entire physical condition, so the Rorschach interpreter, while noticing signs, comes to no conclusions until he has cautiously investigated the interplay of forces of the personality.

I wish to emphasize most strongly that I am fully aware that many if not most of the brief statements made with respect to interpreting a Rorschach protocol require qualification and further elaboration. If qualification and further elaboration were attempted, this discussion would of necessity take a form far beyond its intended scope. Rorschach literature is already assuming voluminous proportions.

Actually, the Rorschach expert must be a psychologist and an experienced clinician as well, just as the roentgenologist must be a physician with a good background in anatomy, physiology, and clinical medicine. In the hands of the layman or even the well-intentioned amateur the technique is useless.

ANOTHER type of projection technique has been devised by Dr. Henry Murray, Director of the Harvard Psychological Clinic. This method, known as the Thematic Apperception Test and familiarly abbreviated TAT, has, like the Rorschach, been found to be a valuable instrument in revealing an intimate picture of the personality within a remarkably short time. Most clinical psychologists find that their Rorschach interpretation can be confirmed and can also be considerably enhanced and enriched with the administration of the TAT. As Murray

points out, the two tests yield complementary information.

The plastic material, the film for the projections in the case of the TAT, consists of a series of pictures presented singly to the subject. The subject is instructed to devise stories about the situations and characters depicted.

The value of the test lies in the fact that human beings tend to read their own meanings into the pictures. The subject externalizes, projects his own experiences, his own feelings and needs, onto the stimulus material. To facilitate the subject's identification with the characters represented, the pictures contain both men and women of various ages.

Murray has aptly expounded on the rationale of the test as follows:

> If the pictures are presented as a test of imagination, the subject's interest, together with his need for approval, can be so involved in the task that he forgets his sensitive self and the necessity of defending it against the probings of the examiner, and, before he knows it, he has said things about an invented character that apply to himself, things which he would have been reluctant to confess in response to a direct question. As a rule, the subject leaves the test happily unaware that he has presented the psychologist with what amounts to an X-ray picture of his inner self.

The material of the test consists of two sets of ten pictures—twenty pictures in all—that were carefully selected because of their effectiveness in eliciting material of diagnostic significance.

Murray found from experience that the stories are more revealing and the validity of the interpretations is increased if most of the pictures include a person who is of the same sex as the subject, although eleven of the pictures were found suitable for both male and female subjects.

An hour is devoted to each set. This would allot about five minutes per picture. It has been deemed advisable to space the two sets by a day or more in order not to tire the subject.

As in every psychometric procedure, the subject must be at ease and cooperative in order to secure the best results. Since the technique is aimed indirectly at eliciting vital material, it is the special function of the psychologist to establish rapport, a friendly relationship with the subject conducive toward this aim.

A brief explanation about the test is usually tendered the subject after he has been made comfortable, as in the preliminary to the Rorschach Test.

The exact words, Murray feels, should depend on the age, intelligence, and the circumstances of the subject. The following instructions from Murray's TAT *Manual* are generally suitable for most adults of normal intelligence.

> This is a test of imagination, one form of intelligence. I am going to show you some pictures, one at a time, and your task will be to make up as dramatic a story as you can for each. Tell what has led up to the event shown in the picture, what the characters are thinking about and what emotions they are feeling, describe what is happening at the moment; and then give the outcome. Speak your thoughts as they come to your mind. Do you understand? You can devote about five minutes to each story. Here is the first picture.

The average length of stories invented by adults, presumably if adequate rapport has been established, is approximately three hundred words. The words of the subject should be transcribed, and, although a concealed recording device is ideal, most psychologists must of necessity write by hand.

After the second set of pictures has been exhausted in the subsequent session, it has been found useful to determine the sources for the subject's narratives. Many of the sources lead back to the individual's past and may be important to the problem at hand.

Scoring the TAT is a far less formidable undertaking than in the Rorschach, and the psychologist is by no means strictly bound to Murray's rather involved scoring technique. Murray is not mandatory here and feels

that whether analysis should be in accordance with a comprehensive conceptual scheme or should merely examine a few personality traits depends on the purpose of the psychologist in administering the test.

Although psychologists have abbreviated Murray's scoring, for optimal results it is probably best to abide by his analytical and scoring techniques. A brief summary of his method follows.

In analyzing a story the psychologist's first problem is to distinguish the character with whom the subject has identified himself. For all practical purposes this character is the hero. The characterizations of the heroes should be studied for such traits as superiority, inferiority, criminality, solitariness, belongingness, leadership, and quarrelsomeness. The subject usually projects himself in the role of hero, and the traits that he assigns to the imaginary character may well apply to himself, or he may be describing his ego-ideal.

It is pertinent to observe in the minutest detail what each of the successive heroes thinks, feels, or does, and here the clinician is called upon to draw on his fund of psychopathological experience to the fullest in order to discern anything that is unusual or uncommon.

Not only is the attitude of the hero important, but the entire environmental situation must be taken into consideration. In other words, all elements which confront the heroes, whether they be physical objects or human characters, play a part in the subject's projection. The psychologist must observe whether other human beings are friendly or unfriendly, whether a particular sex is preferred, whether older figures are preferred over younger ones.

The strength of the needs that the subject ascribes to his leading characters is classified by Murray in the following manner: Responses are rated from one to five depending on the intensity, duration, frequency, and importance to the plot. For example, a mild beratement would be scored as one, whereas a violent assault would be scored as five. Thus the average and the range of variables for representative groups could be obtained by adding the score of each need for the two sets and then combining them to yield a total for each separate need. Murray scores for twenty-eight needs: i.e., dominance, achievement, destruction, sex, etc.

Since the subject places his chief characters in manifold situations during his narrative, it is important to the psychologist to determine how extreme or how temperate the subject is in creating a milieu about his heroes.

Here, too, Murray's classification of thirty kinds of environmental forces and situations (press) is utilized. The criteria for scoring would again be the intensity, duration, frequency, and general significance to the plot. For example, if the hero is exposed to a rainstorm, he is placed in a far less dangerous predicament than if he were exposed to a tornado at sea, and the psychologist would score accordingly. A partial list of press follows: affiliation, rejection, physical danger, physical injury, etc.

It is significant to examine the consequences of the narration. Did the hero dominate, or was he dominated? What stipulations are there for success and for failure? What punishment is meted out for transgression? Does the hero feel guilty, confess, reform, or does he continue unscathed? What is the relationship of happy to unhappy endings?

The following response taken from H. A. Murray's *Explorations in Personality* is illustrative of one type of narrative which the test may elicit. In Picture No. 13 of the test a boy is depicted huddled against a couch, his head bowed on his right arm. An object that resembles a revolver lies on the floor.

Some great trouble has occurred. Someone he loved has shot herself. Probably it is his mother. She may have done it out of poverty. He, being fairly grown-up, sees the misery of it all and would

like to shoot himself. But he is young and braces up after a while. For some time he lives in misery—the first few months thinking of death.

Here the possible death of the mother appears as a determinant of his present pessimism. The story is one variety of a large class of complex themes—the Tragic Love theme.

The subject who gave this response, a Ph.D. candidate, had suffered great hardships in his childhood and, in commenting on his narrative, acknowledged that it was derived from his past and that he had feared his mother might kill herself because of her struggles against seemingly insurmountable poverty.

In summary, both of the investigational methods presented here offer relatively plastic fields with unstructured or loosely structured situations. Despite the artificiality of asking an individual what ink blots mean to him or to devise a narrative about a picture, both tests are potent instruments in exposing underlying factors and influences of the subject's private world. These techniques do not exhaust the possibilities for exploring the personality by any means. The development of new tests and the elaboration and improvement in interpretation of the two tests described may still be regarded as mere beginnings in the ambitious attempt on the part of the psychologist to catch an imprint of the personality.

BACK ISSUES WANTED

The unexpected addition of more than 2,000 new A.A.A.S. members between January 1 and May 1, 1947, has led to a shortage of copies of the February and May 1947 issues of The Scientific Monthly. *The reason for this shortage is that each new member in the first six months of the year has been sent back issues of the journal of his choice. Receipt of copies of these issues from members who do not maintain permanent files will be greatly appreciated. They should be sent to: American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington 5, D. C. Postage will be refunded.* —Ed.

COPPER RESOURCES OF THE UNITED STATES

By BENJAMIN MOULTON

Professor Moulton expects soon to receive his Ph.D. from Indiana University. He is now Assistant Professor of Geography at the Florida State College for Women, Tallahassee. His primary interest is in climatology.

THE United States is unique in her position as major producer and major consumer in the world copper market. American interests control 68 percent of the copper industry of the world as well as a large share of the world's reserves. Normally, the United States produces annually about one-half of the world's copper, consumes somewhat less than half, and controls two-thirds of the production beyond the national boundaries in the Western Hemisphere. A brief analysis of these outstanding facts and their causes follows.

The physical properties of copper that enable it to be widely used are:

1. High electrical conductivity.
2. High heat conductivity.
3. Ductility.
4. Malleability.
5. Noncorrosive qualities.
6. Alloying qualities.

These qualities give to the electrical and machine industries a metal that meets most of their requirements. Copper is also available in quantities that make it economical for a wide variety of purposes.

The United States deposits are widespread, although the most important producers are located in the Western states. Arizona leads, with mines at Morenci, War-

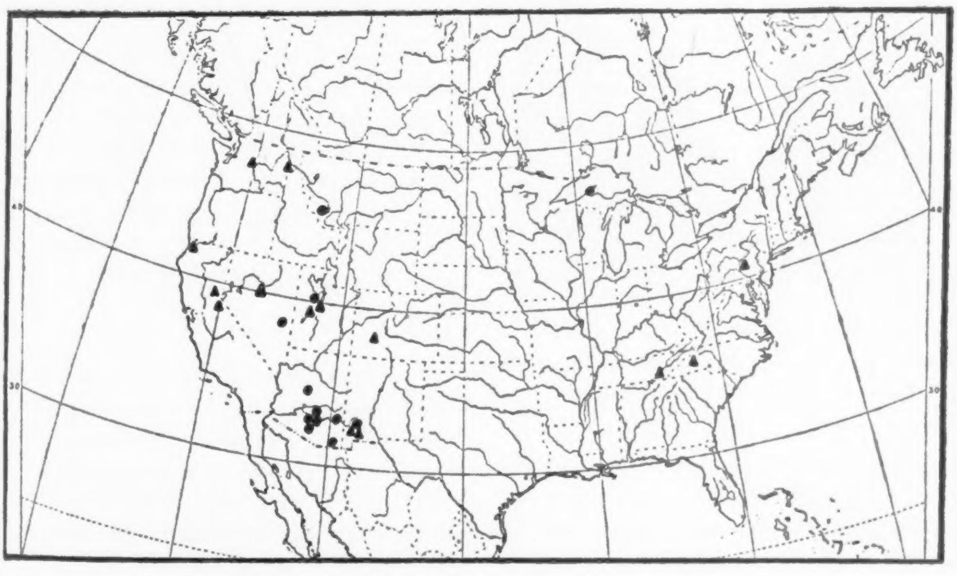

FIG. 1. THE LOCATION OF THE LEADING PRODUCERS OF COPPER IN THE U. S.

BLACK DOTS INDICATE MINES PRODUCING 10,000 OR MORE SHORT TONS OF METALLIC COPPER PER YEAR IN 1943. TRIANGLES INDICATE LESS IMPORTANT PRODUCERS. INFORMATION FROM *The Minerals Yearbook*, 1943.

ren, Globe-Miami, Ray, Ajo, Jerome, and Superior. These seven districts produce 98 percent of Arizona copper, Morenci being the leading producer. Since 1845 about one-third of the copper produced in the United States has come from Arizona.

Utah is the next largest producer of copper today; the important mines are all located in the Bingham district. These deposits also yield large quantities of gold, silver, lead, and zinc as well as copper and molybdenum. The Utah Copper Mine is the second largest in the world, Chuquicamata, of Chile, alone exceeding it in reserves.

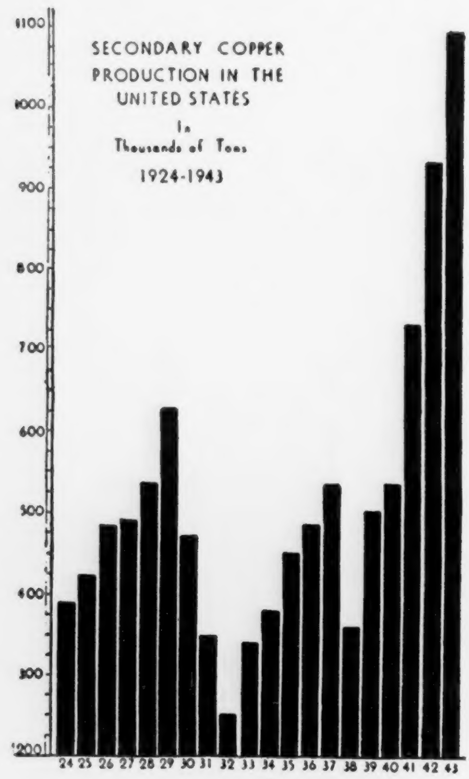

FIG. 2. SECONDARY COPPER OUTPUT

DATA DERIVED FROM NEWTON AND WILSON AND FROM *The Minerals Yearbook* OF VARIOUS DATES.

Montana is ordinarily third in copper production for the United States; a single mine in the Butte district produces more copper than any other mine in the United States.

The locations of the principal districts in this country are shown in Figure 1. Those producing more than 10,000 short tons of metallic copper are indicated by circles; those producing less, by triangles. During the war many minor producers came into operation.

Copper in the United States occurs, for the most part, in five forms—oxides, sulphides, silicates, carbonates, and metallic copper. The only metallic copper deposit of any importance is in Michigan; this deposit is becoming less accessible with the increasing depth of the mine.

An association of minerals is often characteristic of the copper deposits of the western United States, silver, gold, zinc, and lead often being obtained as by-products. The accessory minerals are not so important to the copper mining industry as a whole as to the individual mine, whose profits may depend upon them. Nevertheless, the significance of these associated minerals should not be overlooked.

The United States copper ores are low-grade, often far lower than those in other areas of the world—particularly Chile and Katanga-Rhodesia, whose ores average 2-4 percent copper. The characteristically low-grade ores have necessitated the construction of concentration mills at the mines, and nearly all copper is concentrated at the producing area.

If a map showing the location of the copper-mining areas of the world outside the United States proper were analyzed, it would be evident that the producing areas are in general quite remote from the consuming areas. Not only are they remote, but they are characteristically in geographically unfavorable areas, such as deserts or mountains. Such unsatisfactory geographic conditions have necessitated large expenditures for construction, maintenance, and trans-

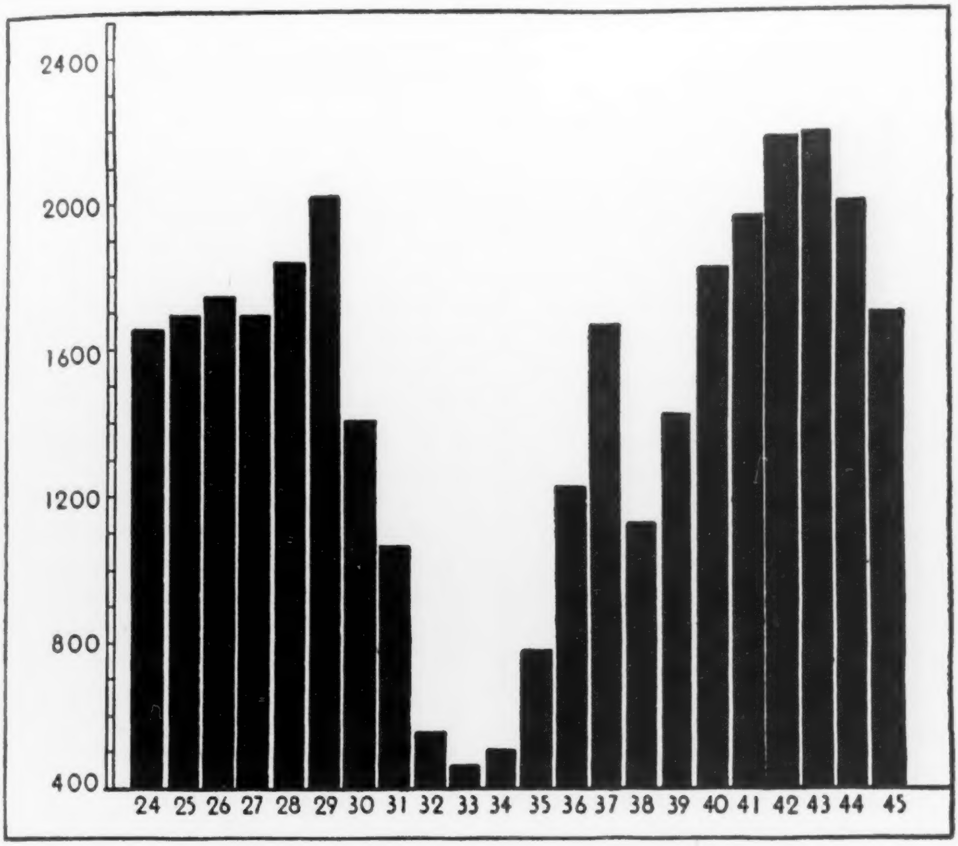

FIG. 3. COPPER PRODUCTION IN THE UNITED STATES, 1924–1945

DATA, IN MILLIONS OF POUNDS, FROM VARIOUS SOURCES; THAT FOR 1944 AND 1945 FROM *Current Business*.

portation. Outstanding examples of localities that export most of their copper are Chile and Katanga-Rhodesia.

Smelters are located in the producing area only if it is a large one, since smelters require a considerable financial outlay and are therefore constructed only where production over a long period of time makes smelting profitable.

Copper refineries, in addition to being located in regions that will insure an adequate supply of raw material over a long period of time, are found in two types of sharply differentiated areas. The older copper refineries were located in the consuming areas. A map showing copper refineries will reveal a cluster in the eastern United States, Belgium, Germany, and Great Britain. Other refineries are located in areas having ample amounts of available water power. Thus, there are refineries at Chuquicamata and Potrerillos, Chile, as well as at Tacoma, Wash., and Great Falls, Mont.

The concentration of refineries in the eastern United States (eight out of the eleven United States refineries being located east of the Mississippi) has resulted in a high degree of control by American financial interests over the copper industry. Much of the foreign ore brought to the United States is refined here and shipped without tariff payments. The amount of foreign ore

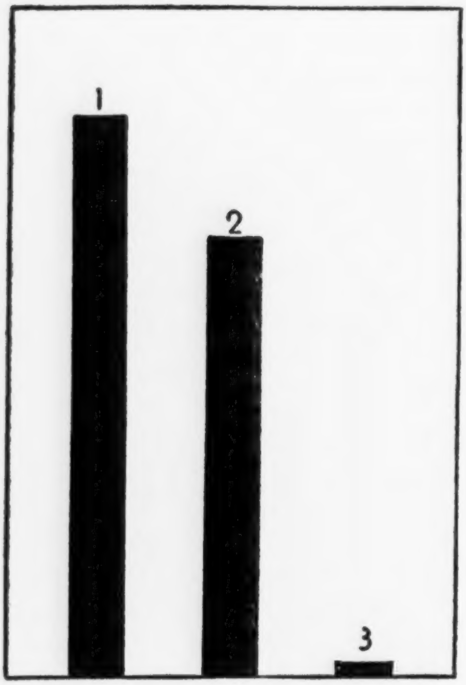

FIG. 4. U. S. OUTPUT AND RESERVES

IN MILLIONS OF POUNDS: 1. PRODUCTION, 1845–1943, 61,290; 2. RESERVES, 48,017; 3. PRODUCTION, 1945, 1,683. FROM *The Minerals Yearbook*, NEWTON AND WILSON, AND *Current Business*.

shipped to the United States is not large, however, and in prewar days most copper from foreign sources such as Chile was shipped to northwestern Europe.

The consuming centers for copper are near the group of older refineries, the largest centers being in northeastern United States and northwestern Europe. These consuming centers are near areas of machine and instrument manufacture, and a brief study of the major uses of copper would show that the greatest users of copper are the electrical and automobile industries.

The status of the copper industry in the United States is depicted by the four graphs (Figs. 2, 3, 4, and 5). An analysis of these diagrams and their relative values may give a clearer picture of the copper industry of the United States. In an age when many mineral supplies are being depleted, the conservationist looks carefully at all mineral resources, including copper.

Unlike many minerals, copper has a rather high junk or scrap-recovery rate. Metal so recovered is classified as "secondary copper," in contrast to the new metal from ores, which is classified as "primary copper."

In many cases secondary copper is preferred since it actually represents a high copper content material to work with compared to copper ore, although more care must be taken in refining to break down any alloys that may be present.

The importance of secondary copper in the United States is indicated by Figure 2. Ordinarily, the amount of secondary copper produced is about one-half that of primary copper. In times of poor primary copper production, there are correspondingly poor years of secondary production (Figs. 2 and 3). Likewise, in good years when the demand for copper is high, both production and prices rise. During these times the salvaging of secondary copper is economically advantageous and recovery increases. The recent trend toward the use of secondary copper is the result of war demands, but figures for earlier years reveal that there has been a wide variation in the amount of secondary copper used. The graph does illustrate clearly that the amount of secondary copper available is large when the demand is present. In any analysis of the status of the United States copper industry, it would be wise to recognize that there is a large but undetermined amount of secondary copper in reserve. An estimate would perhaps place secondary copper reserves available 30 years from now at about 200,000 million pounds.

Primary copper production in the United States is illustrated by Figure 3. The highest production was in 1943, and the largest monthly production was in March

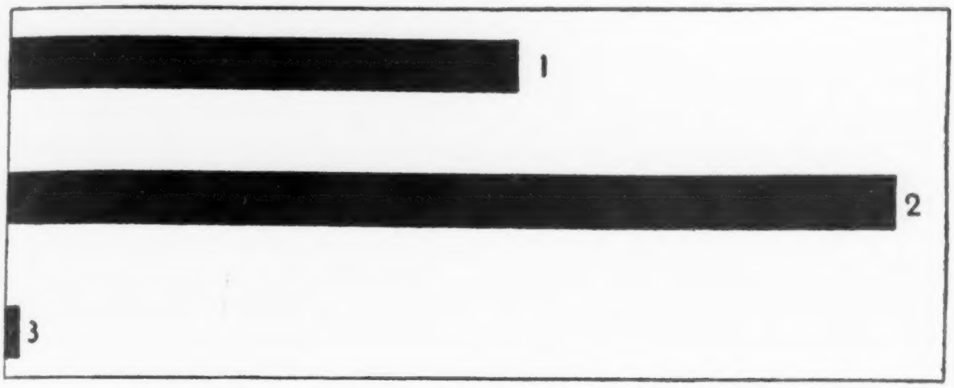

FIG. 5. COPPER PRODUCTION AND RESERVES OF THE WORLD

IN MILLIONS OF POUNDS: 1. PRODUCTION, 1801–1940, 126,775; 2. RESERVES, 219,109; 3. PRODUCTION, 1938, 4,367. DATA OBTAINED FROM *The Minerals Yearbook* AND NEWTON AND WILSON.

1943, when over 200 million pounds came from the smelters. Production decreased after that date as a result of—

1. Decreased labor supply caused by the drafting of men.
2. Increased use of secondary copper representing high ore value.
3. Stock-pile accumulations of the past three years.
4. Diversion of Chilean copper to the United States rather than to European markets.

The copper production of the United States is subject to wide fluctuations, depending upon world economic conditions. In poor years only about one-tenth of the normal supply of primary copper is produced.

These two types of copper (primary and secondary) indicate how much and to what extent copper is being produced in this country for domestic and export use. If one is to make a satisfactory analysis of the status and probable endurance, these two items must be evaluated in relation to reserves. Figure 4 indicates the production of smelter copper in the United States. Item 1 of the figure indicates total production of primary copper from 1845 to 1943 and represents about one-fifth more than the estimated reserves in the United States based on grade ores now being used. Item 3 indicates the production in 1945. At the present rate of production, the reserves would last about 30 years if secondary copper were not used and normal trade were carried on. At the rate copper was produced in 1933, the reserves would last 120 years. The table reveals clearly that our estimated reserves are less than our production so far. With estimated uses of secondary copper and our present rate of consumption, our copper supply could last about 160 years at 1943 production rates.

Figure 5 indicates similar statistics for the world. The remarkable feature of this graph in comparison with the preceding one is that the world reserves are much greater than production. This, of course, is due to the greater usage of metals in the highly mechanized and industrialized United States and to the fact that the United States exports about 20 percent of her annual copper production.

SCIENTISTS AND SOCIAL RESPONSIBILITY*

By P. W. BRIDGMAN

Dr. Bridgman (Ph.D., Harvard, 1908) has been Hollis Professor of Mathematics and Natural Philosophy at Harvard since 1926 and has been in the Physics Department there for nearly four decades. He is well known for his experimental investigation of various physical effects of high pressures. In 1946 he received the Nobel Prize for physics.

THE topic proposed for this symposium, "How far can scientific method determine the ends for which scientific discoveries are used?" is obviously of much generality and also, I am told, of an intentional vagueness. The general background of the topic is plain enough; the topic has evidently been suggested by the present atmosphere through which society is looking at science, inspired by the preponderating role of invention and the applications of scientific discoveries in the late war, culminating in the atomic bomb. Not only is the general public becoming increasingly conscious of the impact of science on the whole social structure, but the scientist has himself in the interval since Hiroshima displayed a noteworthy concern with the social effects of his discoveries. This has resulted in the formation of societies of scientists dedicated to controlling as far as possible some of the aspects of scientific discoveries. There is growing up among scientists a more or less articulate philosophy of what the relation should be between science and society as a whole. It seems to me that it is a matter of the greatest importance what this philosophy is, and that it may well be determinative of the future course of civilization.

There are, I think, unfortunate features in the present trend of this philosophy, and I should like to devote part of this discussion to them. This will involve giving a rather broad and liberal interpretation to our topic. I would in any event be constrained to place a liberal interpretation on it, because it is my feeling that the "scientific method," in the narrow sense in which scientific method is often understood, does not have a very immediate application to determining the ends for which scientific discoveries are used. I like to say that there is no scientific method as such, but rather only the free and utmost use of intelligence. In certain fields of application, such as the so-called natural sciences, the free and utmost use of intelligence particularizes itself into what is popularly called the scientific method. From this point of view I should like to rephrase the topic for discussion to read "What is the most intelligent way of dealing with the uses of scientific discoveries?" A discussion from this broad point of view will necessarily involve aspects of social philosophy, and in particular the philosophy of the relation of science to society.

The detailed discussion might well start with such questions as: How far is it desirable that scientific discoveries be controlled? or, What "ought" to be the attitude of the scientist toward his own discoveries? No discussion along these lines will get very far before the word "responsibility" occurs. Let us examine the implications of this word. It is frequently stated that science is responsible for the uses made of scientific

* This article and the one following are based on papers presented at a symposium on "How Far Can Scientific Method Determine the Ends for Which Scientific Discoveries are Used?" at the annual meeting of the A.A.A.S., Boston, December 1946, in a joint session of Sections K and L and the American Philosophical Association.

discoveries. This is obviously a highly abstract statement. The meaning must be that *scientists* are responsible for the uses made of scientific discoveries. But even this is so general as to have little meaning. Does it mean that scientists as a group are responsible? But what is responsibility that it can pertain to a group? Here we begin to encounter shades of meaning and ambiguities in the word responsibility itself. A few people apparently use the word in a purely factual sense with no further connotations. From this point of view it can certainly be said that scientists are "responsible" for the uses made of scientific discoveries, for the simple reason that the discoveries cannot be used until after the discoveries are made, and the discoveries are undeniably made by scientists. Responsibility in this sense merely denotes a link in the causal chain. But I believe that this colorless and factual use of the word is comparatively rare. The more conventional usage implies a moral obligation and involves a moral condemnation if the obligation is not met. To say that "scientists are responsible for the uses made of scientific discoveries" implies, according to what I believe is the usual usage, that each and every scientist has a moral obligation to see to it that the uses society makes of scientific discoveries are beneficent. This is getting pretty near home. It means that *I* have a moral obligation, and that if I do not meet the obligation I shall be deemed culpable by society and may justifiably be disciplined. The discipline that would be imposed is the natural and obvious one, namely, loss of scientific freedom. This is, I think, the temper of an important part of society today, and the attitude seems to be growing. Furthermore, it is an attitude in which a number of scientists, particularly those of the younger generation, are showing a tendency to concur. Any such concurrence arises, I believe, from a failure to realize the larger implications and involves an essentially short-range philosophy of the relation of the individual to society.

I think it is obvious that the thesis that the scientist is responsible for the uses made of his discoveries must involve the assumption that there is something special and exceptional in the situation. For certainly in more common situations individual responsibility is not considered to extend to all the consequences that may be initiated by the act of the individual. The miner of iron ore is not expected to see to it that none of the scrap iron which may eventually result from his labors is sold to the Japanese to be used against his country. Such an extension of responsibility would be absurd because of the impracticality of it, and in particular would make impossible that specialization and division of labor that is one of the foundation stones of our modern industrial civilization. Furthermore, it is obvious that if such detailed and individual responsibility were imposed a certain ideal of society implicit in the thinking of many of us would have to be abandoned. The society of this idealized vision is a society so constructed that every individual in it may be allowed to strive to choose for his lifework what he can do best. Unfortunately, society is still tragically far from this ideal for the average man, but our departure from the ideal arises, not from failure of good intentions, but from the practical difficulty that we have not yet found a mechanism that makes this possible. However, many individual scientists, so far as they have been allowed to follow the driving force of their inner scientific compulsion, have come pretty close to this ideal. From the point of view of society, the justification for the favored position of the scientist is that the scientist cannot make his contribution unless he is free, and that the value of his contribution is worth the price society pays for it. The demand that the individual scientist be responsible for the uses made by society of his discoveries would constitute

a repudiation of this ideal. For if I personally had to see to it that only beneficent uses were made of my discoveries, I should have to spend my life oscillating between some kind of a forecasting bureau, to find what might be the uses made of my discoveries, and lobbying in Washington to procure the passage of special legislation to control the uses. In neither of these activities do I have any competence, so that my life would be embittered and my scientific productivity cease.

The thesis of the responsibility of the individual scientist therefore involves a repudiation of the general ideals of the specialization and division of labor, and the ideal of, as far as possible, each man to his best. This repudiation can be justified only by some special feature, and the only justification that I can see which is to be taken with any seriousness is the thesis that scientists are in some special way qualified to foresee the uses society will make of their discoveries, and to direct and control these uses. This thesis does indeed seem to be tacit in much of the popular discussion. The question now is whether this thesis is true, and, if so, whether it constitutes justification for the imposition of responsibility. As a physicist with pride in my profession, I would naturally be loath to admit that a physicist could not do a better job than outsiders in controlling the uses made of discoveries in physics, but nevertheless I think an inspection of such activities of physicists as their attempts during the last year to get through Congress a bill establishing the National Science Foundation would show that the batting average of even the physicist would presumably be so low as to make it unprofitable for society to support him in the role of prophet and administrator. For of course society must recognize that if it imposes responsibility on a man it must be prepared to support him in the exercise of that responsibility.

Leaving further elaboration of this question to the tender mercies of others, I now address myself to the question of whether, even granted that scientists are specially qualified to foresee, direct, and control the uses made of their discoveries, society should therefore hold them responsible for the uses made of their discoveries? I think that the temper of the times is such that many people would answer this question with an unqualified yes. Such an answer implies a social philosophy that has been growing rapidly in this country, namely, that the community has a right to exact disproportionate service from special ability. It is epitomized in the Marxian epigram "From each according to his ability, to each according to his need." Three stages of evolution can be recognized in the present philosophy of the relation of the individual to society. The first granted the right of the bright people to exploit the stupid ones; the second recognized the right of everyone to receive from society a reward proportional to his contribution to society; and the third and present stage recognizes the right of the stupid people to exploit the bright ones. It is perhaps obvious that my sympathies are with the second, or the median, of these three philosophies. The third philosophy, insofar as it involves anything beyond the more or less disguised willingness of the majority to use naked force, is based on a metaphysical concept of society as some superthing, transcending the individuals who compose it. This, to my way of thinking, does not make sense. Society is composed of you and me; society does not have an individuality of its own, but is the aggregate of what concerns you and me. The function of society is expressible in terms of its relations to the individuals who compose it, and any justification for the acts made by its members is to be found only in the effects of these acts on the members of society as individuals.

It seems to me that the thesis of the right of society to exact disproportionate service from special ability can be analyzed very simply. If society exacts disproportionate service, this means that certain individuals in society, acting in their collective capacity, are willing to exact disproportionate service from other individuals. But I, as an individual, would certainly not presume to think of demanding that my neighbor give me special service merely because nature had endowed him to do the job better than I could do it myself. The sort of thing I am unwilling to do in my individual capacity I am also unwilling to do in my capacity as a member of a group. Furthermore, it seems to me only decent and self-respecting for me to do my best to see to it that the group to which I belong does not act in a way in which I as an individual would not be willing to act. If every member of society applied to his social acts the same criteria of decency and self-respect that he applies to his individual acts, the problem of the exaction by society of disproportionate service from special ability would not arise.

The assumption of the right of society to impose a responsibility on the scientist which he does not desire obviously involves acceptance of the third philosophy, that is, the right of the stupid to exploit the bright. There are, I believe, specific objections to the application of this philosophy in the present situation, apart from the general considerations just mentioned. It is not necessary. Society can deal with the issues raised by scientific discoveries by other methods than by forcing the scientist to do something uncongenial, something for which he is often not fitted. The course of action that can accomplish this seems to me the only self-respecting one. The applications made of scientific discoveries are very seldom made by the scientists themselves, but are usually made by the industrialists. It is the manufacture and sale of the invention that should be controlled rather than the act of inventing. This could surely be accomplished by specific action rather than by throwing out baby and bath together. One can think of revisions in the patent laws, for instance, that would be pertinent. Or society can control the situation by other means already in its possession. If it had not wanted to construct an atomic bomb, it need not have signed the check for the two billion dollars which alone made it possible. Without this essential contribution from society the atomic bomb would have remained an interesting blueprint in the laboratory.

Why is it that there is such popular clamor for dealing with this situation by the tremendously clumsy and backhanded method of imposing responsibility on the individual scientist, a method which involves the sacrifice of fundamental principles and the development of social mechanisms of more than doubtful practicality? I suspect the clamor arises from the unconscious operation of very human motives. The cry of responsibility is often no more than the cry of a lazy man to get someone else to do for him what he ought to do for himself. There may perhaps be a small element of despair in the clamor. It is obvious that if society would only abolish war, 99 percent of the need for the control of scientific discoveries would vanish. Furthermore, it is obvious enough that the abolition of war is the business of everyone. The difficulties of doing this, however, appear to have become so enormous that the average man may well despair of being able to accomplish it himself. Into this situation comes the vision that if only some *deus ex machina* would stop scientific discoveries from being put to bad uses we could all be at peace in our minds. Whereupon the human race, with its capacity for wishful thinking and rationalization, needs only this hint to invent the legend of the responsibility of the scientists for the uses

society makes of their discoveries. Let society deal with this situation by the means already in its hands, means by which it deals with similar situations. If it truly believes that the peculiar qualifications necessary to deal with the misuse of scientific discovery are to be found among the scientists, which I, for one, very much doubt, then let it create mechanisms and make opportunities by which those scientists who can do this sort of work well will be attracted to this field, rather than to insist on its right to the indiscriminate concern of all scientists with this problem. And let the scientists, for their part, take a long-range point of view and not accept the careless imposition of responsibility, an acceptance which to my mind smacks too much of appeasement and lack of self-respect.

I believe it to be of particular importance that the scientist have an articulate and adequate social philosophy, even more important than that the average man should have such a philosophy. For there are certain aspects of the relation between science and society that the scientist can appreciate better than anyone else, and if he does not insist on their significance no one else will, with the result that the relation of science to society will become warped, to the detriment of everyone.

The social philosophy which seems to be spontaneously growing up among some of our scientists is, I believe, a short-range and inadequate philosophy. It is well known that the scientists who have shown the most articulate concern with the social implications of the atomic bomb are young. The philosophy that is coming into being betrays this. It is a youthful philosophy, enthusiastic, idealistic, and colored by eagerness for self-sacrifice. It glories in accepting the responsibility of science to society and refuses to countenance any concern of the scientist with his own interests, even if it can be demonstrated that these interests are also the interests of everyone. Such a philosophy is unmindful of long-range considerations and blind to the existence of other scales of values than those of the philosophers themselves.

What are the characteristics of an adequate social philosophy? It seems to me that first and foremost this should be a "maximum-minimum" philosophy. That is, society should be so constructed as to allow the maximum number of its members to lead a good life, while at the same time the minimum of dictation and interference should be imposed on any individual in determining what shall for him constitute a good life. The most outstanding characteristic of such a society is its tolerance. What would be a good life for one man would not be a good life for another. It is, I think, with regard to this minimum requirement that actual societies are most likely to fail. No society dedicated to a special thesis satisfies this requirement. A totalitarian society, such as that of Russia, in which a man may anticipate happiness if he thinks as the majority, but in which he may expect to be liquidated if he opposes it, is obviously not such a society. Neither is the conventional Christian society, with its thesis that the good life is the one devoted to the service of a man's fellows, and with the correlative assumption of the right of the community to impose this ideal on the individual. Both these types of society are too narrow. The broadly tolerant society, committed to no special thesis as to what constitutes the good life, is evidently a late product in the evolutionary chain. When the struggle for survival is too intense, tolerance may well be a luxury society cannot afford. But as the struggle for survival ceases to dominate the social pattern, an increasing amount of tolerance becomes practical, until in the end the attainment of the maximum of tolerance may well become the dominating ideal. This, it seems to me, is the sort of society we should strive for; it also seems to me that in this country

today a high degree of realization of such a society is possible.

WHAT is the relation of the scientist to such a society? It seems to me that he occupies a position of high strategic importance, a position impossible of attainment for the man who has not directly experienced the significant factors basic to this type of society. The conception of what constitutes the good life does not present itself as a primitive datum in consciousness, but is a product of cultivation and education. Furthermore, various ideals of the good life are possible, competitive with one another and to a certain extent mutually exclusive. The ideals that come to prevail will to a large extent depend on the self-conscious activities of those most concerned. It may even be that the ideals will have to be fought for. What constitutes the good life for the scientist does not at once appeal to the majority as constituting the good life. Nay, more than this, without education the majority cannot be trusted to see that it is to the advantage of the community as a whole that the scientist be allowed to lead his good life. With education, however, I believe that this can be accomplished, and that the scientist is strategically situated to impart this education. It is, of course, easy for anyone to see that the material benefits we now enjoy would not have been possible without scientific activity and to see that for this reason science should be supported. What I have in mind, however, is something less material. I think the scientist, in endeavoring to impart the vision of what this is, would do well not to take a too narrow view. The scientific life, which for him is a good life, is a special kind of a more general life which is also a good life, namely, the life of the intellect.

I think the scientist's most important educative task is to get the average man to feel that the life of the intellect not only is a good life for those who actively lead it, but that it is also good for society as a whole that the intellectual life should be made possible for those capable of it, and that it should be prized and rewarded by the entire community. It is perhaps a gamble that society as a whole can be made to feel this. But I believe it is a gamble to which the scientific man is committed. If the human race is such a sort of creature that it cannot be made to feel that intellectual activity and satisfaction of the craving for understanding are goods in themselves, then we might as well shut up shop here and now, and those of us who are made that way henceforth get the intellectual satisfactions necessary to us as best we can, surreptitiously and in spite of our fellows. Example itself can be educative. Appreciation of the element of high adventure in achieving understanding of the ways of nature should not be difficult to impart. In other fields human beings do this. There must be widespread sympathy with, and understanding of the mountain climber who, when asked why he had to climb mountains, replied, "Because the mountain is there." I believe that most men similarly can be made to feel the challenge of an external world not understood and can be made to see that the scientist has to understand nature "because nature is there." The challenge to the understanding of nature is a challenge to the utmost capacity in us. In accepting the challenge, man can dare to accept no handicaps. That is the reason that scientific freedom is essential and that artificial limitations of tools or subject matter are unthinkable. The average man, I believe, can be made to see that scientific freedom is merely freedom to be intelligent, and that the need for this freedom is born with us, and that we will practice it in the inmost recesses of our thoughts no matter what the external constraints. And I believe also that the average man can be made to see that the imposition of restraints on the freedom to be intelligent betrays fear of the unknown

and of himself, and that he can be made to feel that this fear is an ignoble thing. My gamble is that the human race, once it has caught the vision, will not be willing to yield to fear of the consequences of its own intelligence.

It may appear that we have been straying rather far from our ostensible topic. I think, however, that from the broad point of view we have not. What we have been saying amounts to saying that the most intelligent way of dealing with the problems arising from scientific discoveries is to create an appropriate society. This society will be a society that recognizes that the only rational basis for its functions is to be sought in its relations to the individuals of which it is composed; a society in which the individual in his capacity as a member of society will have the integrity not to stoop to actions he would not permit himself as an individual; a society broadly tolerant and one which recognizes intellectual achievement as one of the chief glories of man; a society imaginative enough to see the high adventure in winning an understanding of the natural world about us, and a society which esteems the fear of its own intellect an ignoble thing. In a society so constituted I venture to think the problems created by scientific discoveries will pretty much solve themselves.

INTEGRAL

Each dies a separate death; the blood congeals,
Muscles grow rigid, ice invades the bone;
The heart grinds to a stop, like dragging wheels,
A light goes out . . . and man is left alone.
There is no comfort here; no word can breach
The widening and fathomless abyss
A breath away, yet out of mortal reach—
And there is no aloneness like to this.

Each dies a separate death, alone, apart,
Yet by his very dying he becomes
An integral of one vast, cosmic heart,
One with the dead through all millenniums;
Death isolates, but to unite at last,
With granite link, the present to the past.

MAE WINKLER GOODMAN

THE ROLE OF SCIENCE IN GOVERNMENT

By Felix S. Cohen

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IN SCIENCE no less than in government, I think, it is a part of wisdom to recognize that not every sentence followed by a question mark asks a question.[1] The text for discussion, "How far can scientific method determine the ends for which scientific discoveries are made?" ends with a question mark. But in order for this to pose a significant question two preconditions would have to be met: first, it must be possible for a method to determine an end; and, second, this process of determination must be measurable, so that some constant can be substituted for the variable "how far?" For my part I cannot, for the life of me, understand how any method can ever determine an end. And I therefore see no point in trying to decide whether such a process of determination, if it existed, could be measured. I shall, therefore, not attempt to give an answer to what I think is not a question. Let me instead take this opportunity to treat our text not as a question to be answered, but as a symbolic indication of interest, and perhaps of confusion, that deserves to be explored.

What we are interested in, I suppose, is the question of whether and how human beings can be scientific in marking out social goals, standards, and controls to govern scientific research and technology. The process of influencing, criticizing, and controlling scientific activity is carried on by college trustees, corporate boards of directors, governments, and many other agencies. Because my own knowledge of the mores of college trustees and corporate directors is rather limited, I propose to restrict my comments to the problem of governmental or political influence or control over the activities that comprise science. Specifically, I propose to address myself to the problem of whether we can be scientific in the political control of scientific activities.

Let me at the outset try to dispose of a common language block to clear thinking on this problem. It is frequently said, and even more frequently assumed, that political control of science or technology is either impossible or wholly calamitous. "Political medicine" is the bad name that some physicians like to give to programs of government-subsidized medical service, to save the trouble of arguing the merits or demerits of such programs. Such are the dyslogistic overtones of the adjective "political" that further argument appears superfluous. And perhaps the word "control" has similar overtones. Let us, however, following the advice of Justice Holmes, wash our words in cynical acid and recognize that political factors, in the sense of factors of policy or government, are inevitably involved in the control of technology, and that control is positive as well as negative, including assistance as well as restriction.

Let us, in the same spirit of operational realism, which Professor Bridgman has so ably advocated in the physical realm, recognize that "disciplining" scientists may be only a dyslogistic way of referring to the award of Nobel Prizes, and that the

"right of the stupid to exploit the bright" may mean no more than the duty a great physicist is under to expound his ideas to fellow mortals of lesser intellect. At any rate, the problems remain when emotion evaporates. Research facilities may be taxed or untaxed, publicly subsidized or not, permitted to accept private donations and bequests or not. Free public education may stop at the high-school level or run through college or postgraduate courses. Government agencies may restrict or expand their present research activities in the natural or the social sciences or in both. Which of these possible courses should be followed? And how should the products of government research be distributed to the public? Should inventions that result from government research belong to the public or to the individual government employee who completes the invention? How far should the government go into the atomic-energy business, or into the power business generally? How much freedom should public servants enjoy in publicizing their findings and theories, and who should fix and judge the limits of such freedom? These questions, which seriously affect the future of science in this country, are inevitably political, and we do not guarantee the correctness of our answers by refusing to face such question openly or by failing to appreciate the conflicting considerations that may lead reasonable people to entertain divergent views in answering them.

To say that it is possible, and even desirable, to weigh such political alternatives and questions as these is only to touch the edge of the problem before us. What is more important to recognize, perhaps, is that social control or direction of technology is not only one among many functions of political organization, but, over the span of recorded history, probably the most important single function of political organization.

If we look for instance, to the Stone Age culture of our own Plains Indian society, where the buffalo hunt was the principal source of food, clothing, and shelter, we find that the social control of buffalo hunting was the major axis of political development. The buffalo police came into being in the buffalo-hunting season, when whole tribes and nations united, in order to make certain that no unsocial or unskillful individual hunted in such a way as to frighten away the herds. At other times of the year Plains society was highly individualistic, and single families, bands, or individuals might hunt deer or bear as they pleased, without police supervision. But when the existence of a whole people was at stake and depended upon a minutely elaborated technology for sustenance and survival, a police force was called into being.

So, too, if we look at the irrigation-farming society of the Pueblo Indians, we find a society dependent upon a carefully developed technique of irrigation, and control of the irrigation ditches and the use of irrigation water are to this day the focus of Pueblo government and the ultimate sanction of communal discipline. If we look at the old Southern plantation economy, we find techniques of operation and management that are reflected and supported in the present government machinery of the plantation states. In a society of traders or raiders, government focuses on the canons and techniques of trading or raiding.

At every level of civilization, we find that acts which disturb or seem to threaten the accepted way of making a living are the most serious of crimes. On our old Western frontier men might forgive many departures from the moral codes of the East, but there was no argument about horse-stealing, which cut the thread on which travel, communication, and livelihood hung in the technology of the frontier.

The precarious dependence of all human

living and civilization upon the maintenance of man's technological control over nature is ever-present today. Though the threat of starvation, which has haunted mankind for a million years and still haunts most of the world, no longer looms before our eyes in this blessed land, the atomic bomb has made us all realize that our lives and our children's lives hang in the balance while we seek to fashion effective controls for our technology.

Today we are beginning to realize the inadequacy of the old-fashioned materialism that viewed human development as a product of geography and natural resources, with technology appearing as a by-product of resources. Today we are beginning to appreciate that what is a natural resource is itself a function of our technology or resourcefulness.[2] Human intelligence can make airplane wings out of sea water, fertilizers out of air, little atoms out of big atoms. Set a scientist down in a desert or a wilderness and he will begin to discover resources, wealth, opportunities. Take science from a prospering land and it will relapse into desert or wilderness. If, as a distinguished economist has well said, the fundamental category of economic activity is power,[3] then, as surely as knowledge is power, knowledge is the basis of every economy.

Today a modern scientist may paraphrase Archimedes to say: "Give me control over a nation's scientific development, and a long enough span of years, and I will raise or lower its level of income or power to any assigned point." Compare the strength and the standard of living of a country like Switzerland, incomparably poor in natural resources but rich in vision and skill, with that of Rumania, abounding in natural resources but lacking in science,[4] and you will find a key to many traditional mysteries of international intercourse and of our own national development.

If, then, the control or direction of technology is inevitably a political question and perhaps, as I think, the most central and most important of all political questions, the question that faces us is: What light can science throw on the proper direction of such control?

Perhaps the most persuasive answer to a question of this sort is one given by historic fact. The scientists of this country have undertaken within the past two years to help direct the course of atomic-energy development in this country by cooperating with politicians or, if you prefer, statesmen—if it is ever permissible to apply the term to politicians who are not yet dead. Our physicists and other scientists lectured for some months to a senatorial seminar arranged by Senator McMahon and found a willing audience. As one who played a very minor role in the preparation of testimony and the drafting of legislation in this field, I should like to pay my tribute to the public service rendered by our atomic scientists in awakening and informing public opinion. It was the scientists, speaking with the authority that a preface of thunderclaps assures, who called attention to the dangers inherent in certain legislative proposals in the field of atomic energy. Those proposals might now be law but for objections that scientists then voiced. Those proposals, we soon realized, threatened the basic principle of our American democracy, the thing that distinguishes us from so many sister-republics of this hemisphere, civilian supremacy in government. I think we have taken the first brave steps toward making atomic energy a source of peace and plenty rather than an endless catastrophe. I think we have achieved a reasonable compromise between the need for freedom of research, which is an essential part of free thought, and the need for public control of its military and economic applications.[5] If we have achieved this result, it is because our scien-

tists and our politicians were able to realize that they live in One World. If we have not completely attained the Platonic ideal that will come into being when kings become philosophers or philosophers become kings, we have, I think, made a modest stride in that direction in dealing with atomic energy.

Such a result was possible in the field of national legislation, for one thing, because our Congress, not being limited, as many state legislatures are limited, to meeting for a few weeks every other year, is able to give patient attention to scientific evidence on important political issues, whenever they arise, and to act in the light of the evidence. How Congress has been able to survive the popular Calvinistic theory of the depravity of government which has led to the extraordinary restrictions fastened upon the meetings and activities of nearly all our state legislatures, I do not know. But I think it fortunate for the country that we do have a national legislature that is ready, able, and willing to have the light of science thrown on current problems at any time. Members of Congress are not always scholars, but I see no reason why American scientists should ever hold up their hands in horror at the prospect of educating Congressmen or their constituents on matters that profoundly affect our lives. After all, Socrates was able to demonstrate geometric proofs to a slave boy.

Not only in the field of atomic energy, but in many other fields as well, do we find scientists testifying patiently and effectively before committees of Congress, as to the probable consequences of one legislative course or another. Proposed legislation for the establishment of a National Science Foundation,[6] for the expansion of public health services, and for the interchange of teachers, students, and research workers with other countries evoked effective testimony from distinguished American scientists. And year after year government scientists go before appropriation committees to justify appropriations for government-financed research. Just think what it means to justify an appropriation for research. It means finding a common measure for the impact of taxation on human lives and the probable outcome of a search into the unknown. And it means a choice among competing proposals for disbursing national funds in a field which includes not only many different lines of physical and social research but also works of national defense, subsidies to agriculture, and law enforcement. And despite all the fashionable doubts as to the commensurability of human values, these goods have to be weighed against one another, for each public dollar can be spent only once. If the justification of basic research under those conditions seems a dreary and impossible task to those who have never sat across a table from an appropriations committee, let me quote the reassuring comment of a scientist in the Department of Agriculture:

> I have been going up before appropriation committees for this Department for close to forty years and I never have found a committee that as a whole wasn't favorable to fundamental research, whether we could show any immediate returns or not. In all of my experience, any sound piece of research has always had their support, and I have known them to make appropriations for such types of research even against the recommendation of the Bureau of Budget and the President.[7]

The receptivity of our Congress to impartial scientific evidence on issues of national significance is paralleled, I believe, by the attitudes of most of our executive or administrative agencies. Organizations like the Bureau of Standards, the Bureau of Labor Statistics, the Bureau of Mines, the Geological Survey, the Public Health Service, and the many research agencies of the Department of Agriculture seek not only to trace

the latest technological developments in their respective fields, but also, so far as possible, to measure the human consequences of such developments and to bring this knowledge to bear upon the administration of governmental bureaus. Many of us are discouraged, from time to time, because in one matter or another some administrative body has paid too much attention to an outworn and disproved theory and not enough attention to the latest scientific findings. But do we not often make the same observations about our students and even our academic colleagues? And if we try to take a long-range view of things and compare the amount of up-to-date scientific data that is available to present-day government administration and used in the process of administration, with what was available, say, in the days of Bentham, we can get some conception of just how far we have progressed along the path that Bentham charted, the path of molding law and administration in the light of the human welfare and human suffering that follow therefrom.

As a lawyer I am sorry to have to report that there is at least one field in which the scientific search for truth has hard sledding, and that is before the judicial branch of government. The spirit of the contest by hired champions still dominates litigation, and for the court to go beyond the presentation by interested parties and to embark upon impartial scientific investigation of its own, perhaps with the aid of recognized scientific bodies and authorities, would appear to many judges and lawyers to be an unforgivable departure from the sporting spirit that should control litigation. Yet I wonder whether we have not outgrown the right to rely on hired champions, whether they wield medieval battle-axes or modern theories of psychoanalysis or economics, in our search for the truth in courts of law.

Differences of opinion in our Supreme Court, for instance, as to the consitutionality or even the interpretation of statutes generally turn upon differences of viewpoint as to the "reasonableness" of various statutory requirements, and these differences, while they may turn on ultimate ethical disagreements, seem generally to be based upon divergent views as to the actual consequences of the act or the interpretation in question. Yet there is no recognized way in which the Supreme Court may call upon any scientific body for impartial advice on the facts. The result is that the Supreme Court's pronouncements and assumptions on matters of economics, anthropology, biology, and technology are often made in disregard of the sources of scientific information that are available to Congressional committees. Thus, for example, in the case of *Alcea Band of Tillamooks* v. *United States*, decided November 25, 1946, four justices of the Supreme Court thought that failure to pay Indians for surrendered lands was a departure from accepted mores of government activity, justifying an award of compensation, while three justices dissented from the allowance of compensation on the ground that taking lands from Indians without compensation was the usual and commonly accepted way of doing business a century ago. On this issue of political and economic history neither party to the case presented any evidence at the trial, and the Supreme Court had no way of calling for expert and objective testimony on an issue of historic fact.

The need for access to impartial sources of scientific knowledge is even greater, though perhaps not so dramatic, in the lower courts. Why should a trial judge have to choose between two hired experts testifying for one side or the other on questions of psychiatry, medicine, chemistry, economics, or anthropology? Would it not be helpful in the search for truth if courts could call for testimony from panels of disinterested

scientists nominated by appropriate scientific bodies and paid, not by one party or the other, but out of the same public funds that are available for judicial salaries and other expenses of the administration of justice?

I hope that someday the American Association for the Advancement of Science or some of its constituent organizations will give thought to ways and means of making scientific knowledge available to our courts of justice in an objective and impartial way that will command respect both for our science and for our law. I do not think such a project is by any means fanciful. Our wisest judges have long recognized the dependence of justice upon science.

> I have had in mind [to quote Justice Holmes] an ultimate dependence upon science because it is finally for science to determine, so far as it can, the relative worth of our different social ends, and, as I have tried to hint, it is our estimate of the proportion between these, now often blind and unconscious, that leads us to insist upon and to enlarge the sphere of one principle and to allow another gradually to dwindle into atrophy. Very likely it may be that with all the help that statistics and every modern appliance can bring us there never will be a commonwealth in which science is everywhere supreme. But it is an ideal, and without ideals what is life worth? They furnish us our perspectives and open glimpses of the infinite (O. W. Holmes, Law in Science and Science in Law, *Collected Legal Papers*, 210, 242).

There are today many practical approaches toward such a liaison between science and justice. In many juvenile courts we have trained psychiatrists, criminologists, and physicians attached to the court itself and able to furnish unbiased information to the judge. In some civil cases, where intricate questions of geology, psychiatry, economics, or industrial technology are involved, special masters with scientific training are appointed by the courts to get at the facts. Only a year or so ago new rules of criminal procedures were promulgated for the Federal courts and this code, for the first time in our history (thanks, I believe, to the efforts of my distinguished colleague Professor George Dession), authorizes the Federal courts to appoint expert witnesses on its own motion.[8] We ought, I think, to have some similar procedure in civil cases, and particularly in constitutional cases. And, above all, when the judiciary takes this step toward an effective liaison between science and justice, there ought to be some reciprocal step taken on the part of scientists to see that this affair is a durable marriage and not merely a liaison.

This, of course, is only a small part of the area in which science may function to make government more scientific. As an old bureaucrat who has served for more than thirteen years in the Office of the Secretary of the Interior, I may say that I can think of no more important step toward good government than action by American scientists, through their professional organizations, to subject the scientific assumptions that underlie our laws and their administration to systematic scientific scrutiny. Take, for example, our racial laws, laws which seek to control man's biological development in this country by gerrymandered immigration quotas and the various restrictions on citizenship and land ownership that rest on racial grounds. Is there not some responsibility on the part of biologists and anthropologists and other professional scientists to expose the pseudo science and the disproved hypotheses on which so much of this legislation rests? Of course there may be some who will uphold these laws, whatever the facts may be, and I am not suggesting that tracing the consequences or the assumptions of a given course of political action will ever be enough to defeat or establish such action as a matter of logic. Always there remains a question of ultimate values. I shall recur to this in a moment. For the present I am contending only that the process of government always involves assumptions and hypothe-

ses as to positive fact and that scientists can help to see that these assumptions and hypotheses are considered in the light of the available scientific evidence. In this process we may come to realize that every law and every ruling involves implicit predictions and deserves to be reconsidered whenever these predictions are not borne out by the facts. That, I take it, is one essential of the scientific approach to government and law. To the extent that this approach is implemented in reality, government can become more scientific than it is. Conversely, to the extent that we may have a reaction against "experimenting," "guinea pigs," "questionnaires," "theories," and "professors," government may become a good deal less scientific than it now is.

The upshot of our argument thus far is that the activities of scientists are just as proper a subject of social control as the activities of businessmen, irrigation-water users, patent owners, or horse thieves, that this social control of scientific research and its applications is largely exercised through the usual agencies of government, and that existing governmental agencies in this field are more or less receptive to the influence of scientific data impartially presented, and might be more receptive if scientists put forth a more sustained effort to make their data available to the agencies of government. All this, however, focuses on the role of factual knowledge in enlightening the process of government. Is that all there is to the fixing of social goals?

Such words as "ethics," "morals," and "the good life" have acquired, during recent decades, the musty odor of Sunday-school rooms that are open only once a week. Under the influence of nonscientific conceptions of ethics, and particularly under the view that conscience can give an infallible answer to any ethical question, ethics during the nineteenth century was forced to abandon the empire it once claimed over the world of science, industry, law, and civilization. So attenuated in its dominion, ethics could command respect only by issuing the one command with which every weak sovereign may secure obedience, the unbreakable command: "Do as you please." The morality of *laissez faire*, applied to economics, law, education, art, and science, reflects the bankruptcy of a society in which no group recognizes its obligations to the rest of humanity. Such a fissionable society cannot, I think, long endure. Certainly it cannot long endure alongside other societies where the objectives of all groups are systematized and reasonably coherent.

The search for a systematized and coherent pattern of values is not a new thing in the history of our civilization. In the works of Aristotle and Plato, in the Pentateuch, and in the great synthesis that Scholastic philosophy made of the Hellenic and the Semitic traditions, there is clear recognition of the fact that all human conduct is subject to moral judgment because we all live in One World where all human conduct affects human weal and woe. In the light of this recognition neither science nor art nor education nor law can be removed from the realm in which significant moral judgments may be passed. Conversely, modern ethics cannot ignore the data of science in favor of the promptings of conscience, which is itself, in large part, like common sense generally, a compote of old scientific and philosophical theories that has been stewing for a few hundred or a few thousand years. Modern ethics recognizes that insofar as we pass moral judgment on acts without knowledge of their consequences we literally do not know what we are talking about.

The physical scientist can claim credit for the conquest of energy that has made civilization compatible with human equality by making it possible to substitute mechanical slaves for human slaves. By the same token,

he cannot escape, any more than any other member of society, responsibility for the human suffering he helps bring to pass. And only an informed appreciation of the way in which science operates to relieve human suffering and banish ancient fears and ancient pains can assure to science the social support that it deserves. I think that our society of today is on the brink of rediscovering these ancient truths, and that the famous slogan of a successful American businessman, "The public be damned," is going to find fewer adherents in the coming generation than it has found in the past, not only in the ranks of businessmen, but also in the ranks of poets, painters, lawyers, and scientists. For the arts and sciences, as for the nations, isolationism is obsolete.

Let me hasten to add that I think the pursuit of truth through science is assuredly a good in itself that needs no ulterior justification, any more than love or art or chess or law, conceived as an indoor sport. But when chess is played with human pawns, the pawns as well as the players have a right to be heard. The pursuit of truth, like the pursuit of beauty or happiness or what is called *elegantia juris*, if carried on in a society of many individuals in such a way as to bring destruction or injury to some of them, must appear when called before the bar of some more comprehensive moral judgment. If the scientist lived his entire life in an ivory tower and undertook to destroy the tangible results of his research upon its completion, there might be some ground for the argument that society has no right to interfere or concern itself with scientific research. Perhaps there are some scientists who do live in such towers. A great mathematician once said that the best thing about the theory of prime numbers was that nobody could ever by any chance put it to any practical use. I am not sure that this is still true in these Pythagorean days when our very lives are balanced upon atomic numbers like U-235. But certainly outside the theory of prime numbers there is no field of science that does not have a bearing on human happiness and human suffering, and no field, therefore, from which ethical judgment can be excluded.

Such ethical judgment may be enlightened or unenlightened. It is more likely to be enlightened if scientists themselves, as educators, participate in the process of public enlightenment and participate, as citizens, in the formulation of social policy. And if, as I believe, citizenship carries a duty to contribute knowledge, as well as taxes, in proportion to ability or income—notwithstanding Professor Bridgman's objection on both counts[9]—then the civic duties of the scientist are not negligible.

The question remains: Can ethical judgment be enlightened or is it inevitably a magical or religious but definitely not a scientific affair? Is there an unbridgeable gulf between the world of "is" and the world of "ought," such that the methods of science applicable in the former realm are of no relevance to the latter?

I have elsewhere argued that ethics itself is, at least potentially, a science and that judgments of value can be scientifically analyzed, refined, corrected, and systematized, just as judgments of time, weight, or space can be.[10] For the present it is enough to state the position in agnostic terms. I know of no point at which the scientific search for facts needs to stop short of complete understanding of all the relevant factors in any problem situation.

Most supposed ethical disagreements turn, I believe, upon different estimates as to the actual consequences of alternative forms of conduct. And certainly the tracing of consequences of conduct is a proper domain of science. There is, however, in the last analysis, a point at which one must stop tracing the consequences of any course and judge that in the light of all these conse-

quences the course in question is desirable or undesirable. Does one thereupon move into another world, a world from which science is forever barred?

To distinguish between "is" and "ought" is proper enough, just as it is proper to distinguish between "is" and "is not." The proposition "Hitler is alive" is as different from the proposition "Hitler ought to be alive" as both are different from the proposition "Hitler is not alive." But this does not mean that there is a world of *ought* and a separate world of *is*, any more than it means there is a world of *being* and a separate world of *nonbeing*. The difference between "is" and "is not" is relative; "A is not B" is equivalent to "A is C;" "Hitler is not alive" is no different than "Hitler is dead." So, too, there is, I think, only a relative difference between *is* and *ought*. To say that we ought to avoid an atomic war is, I think, substantially equivalent to saying that we shall, in the long run, avoid a great deal of suffering by averting such a war.

Whether I am right or wrong in considering suffering to be the only intrinsic evil in the world, and well-being or happiness the only intrinsic good, the fact remains that any ethical theory that purports to follow the canons of science must use empirical terms in defining the good life, and I see no reason why any body of empirical observations may not become the material of science if approached in a scientific spirit. I would say that one approaches ethics in a scientific spirit if he has what Professor Bridgman has referred to as the scientist's religious humility before ultimate facts[11] and is ever ready to revise his theory to accommodate the facts.

Now it seems to me that the facts of ethics are as ineluctable as the facts of color. Things appear to us as good or bad, as they appear black or white, large or small, round or square. These observations are not infallible, since, as Kant pointed out, actual observation always involves, in addition to pure perception, a conceptual element which involves judgment. But such observation, whether of color or value or the position of pointers on instruments, offers the only possible material for empirical testing of any theory. Such observations are subject to correction and refinement as we learn how to separate what is actually perceived from the conceptual mass that the observer brings to the relation of observation. But we cannot ever eliminate these observations from the body of any empirical science.

If we eliminated felt time and felt weight and perception of color from physics we should have only a circular and empty mathematical system in which time is the measure of motion and motion the measure of time and neither has any verifiable existence. In the same way ethics becomes an empty logical system if immediate perception of good and evil is eliminated, and yet our observations, in ethics as in physics, are fallible and correctible. Such observations and judgments are perhaps not absolute, but if they are relative to perspectives or coordinate systems we can still hope to find formulas of translation from one system to another or, at the very least, realms of agreement. And although we recognize, with Aristotle, that we cannot expect the same precision in political science as in physics or mathematics, the fact remains that people do agree on some ethical observations about as well as they do on most physical observations. This is shown when, for example, the Senate of the United States passes a bill on atomic energy by unanimous vote. In fact, the essence of politics in a democracy is the search for points at which a multitude of ethical systems with disparate starting points and divergent goals can converge in a common observation. Without such convergences and the political skill to discover them we should have not a society but what Hobbes aptly called a "war of all against

all," on a domestic as well as an international scale.[12]

There was a time when the custodians of the world's science considered the heavenly bodies a proper sphere of scientific interest but looked with disdain upon those who sought to apply similar canons of analysis to such mundane affairs as the rate at which stones fall or pendulums swing or blood flows. Yet the progress of science has always depended upon the happy fact that some scientists have not cringed before these looks of disapproval or bowed before iron curtains and have ever been eager to push the techniques of science to new fields "beyond the utmost bound of human thought." If we are not to put ourselves in the laughing stocks of history alongside the persecutors of Galileo, let us not set limits upon the possibilities of ethical science. Let us not set bounds upon what is truly an endless frontier.

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Book Reviews

THEY MOVE IN THE VOID

Meet the Atoms. O. R. Frisch. xiv + 226 pp. $3.00. Wyn. New York. 1947.

The Atomic Story. John W. Campbell. vi + 297 pp. Illus. $3.00. Holt. New York. 1947.

Explaining the Atom. Selig Hecht. xiv + 205 pp. $2.75. Viking. New York. 1947.

ATOMIC bombs, atomic power, atomic age, atomic scientists, atomic information, atomic, atomic, atomic . . .

Many books are already in existence and are being published on every angle of atomic energy. But *what is the atom?* The book by Dr. O. R. Frisch fills the gap in the existing literature, and those readers who will go carefully through its 226 pages will know at least what they are talking about when they speak of the atom. It supplies this minimum of basic physical knowledge, which is absolutely necessary for the understanding of the questions concerning the immense amounts of energy hidden in the central nucleus of the tiny atomic body.

The author of *Meet the Atoms*, together with Professor Lise Meitner (who wrote the preface to it), was the first to interpret the epoch-making experiments of Hahn and Strassmann as the *fission* of atomic nucleus. During the war Dr. Frisch was active in the Manhattan District, for he was a recognized authority on atomic energy. He is now working in England on the same class of problem. This fact, which guarantees the authenticity and perfectly scientific angle of the presentation, is probably also responsible for the extreme shortness with which the basic problem of nuclear fission and the large-scale liberation of atomic energy is treated in the book. But for those who are interested in the question of *what* the atom is and not *how* to use atomic energy, Dr. Frisch's book certainly represents a well of knowledge.

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THE book by John W. Campbell, *The Atomic Story*, is intended for popular reading and for its greater part is quite successful in its aim. On such a subject as atomic physics, this is no mean achievement; and, if in a few places the author falls below his average standard, this is only what must be expected of a writer on any subject.

The author's treatment of his subject is historical in character. He points out that there have been two lines of discovery in physical science that in recent years have coalesced into one. One of these lines began with the discovery that matter was not continuous but granular in structure; in other words, that there were such things as atoms. Centuries later, it was found that even these atoms were not the ultimate particles of matter, but were composed of still smaller subatomic particles.

Electrical science had a parallel development, beginning with the ancient knowledge of the attractive power of rubbed amber. The author traces the growth of our electrical knowledge from Franklin's time up to the development of the Crookes tube. He then points out that some twenty years later the discovery of radioactive substances brought about the union of these

two lines of development by showing that the subatomic particles were electrically charged.

In the chapters dealing with the subsequent development of these united lines, culminating in the discovery of atomic fission and its application to the atomic bomb, the author is at his best. In some parts, these chapters are not as easy reading as those dealing with the earlier history of the subject and must be read as carefully as the proof of a theorem in geometry; but, considering the advanced nature of the subject, this, too, is only to be expected.

The book closes with a chapter entitled The Human X in Atomic Politics, which contains many good points. It closes as follows:

> There are two great tasks for the next half century: We must learn more about atomic forces. But we'd be wise if, first, we learned more about man—the one greater force that can twist atomic energies to its will.

However, there are in this excellent book a few places where alteration is advisable if opportunity offers in a second edition. On page 18, where the author discusses the attraction and repulsion exhibited by rubbed rods of glass and hard rubber, his treatment leaves something to be desired. For instance, he says in one place: "Since in ordinary uncharged matter there are electrons in numbers just equal to protons, the glass rod will attract bits of ordinary matter because it attracts their electrons." But what about its repulsion for their protons?

The fact is that these phenomena, in the light of our modern knowledge of electronics, are by no means so simply explained as the author does it. He lays emphasis on the friction of silk on glass as breaking off electrons from the surface atoms of the glass, much as a dustcloth wipes off dust and carries it away. The modern view is that the only function of the rubbing is to bring about a close contact between the two substances; then there comes into play the contact electromotive force discovered by Volta, for which we have as yet no perfectly satisfactory explanation.

On page 105 (and several other places) reference is made to the periodic table of elements. The nonscientific reader is not likely to have a copy of this table to refer to; and even the scientific reader might not have for ready reference the special form of the table mentioned by the author, which gives figures for the binding energy for atoms of different sorts. The book should contain a copy of this table.

Mention should also be made of the nonscientific pictorial illustrations. These contribute nothing to the understanding of the subject and can hardly be regarded as ornamental.

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ALTHOUGH there is not a word of politics or sociology in *Explaining the Atom*, it is, nevertheless, by purpose and design, a book that is profoundly provocative in its political and sociological ramifications. By conveying to laymen the intellectual drama of the developments of atomic physics during the past fifty years, Selig Hecht, Professor of Biophysics at Columbia University and honorary Vice-chairman of the Emergency Committee of Atomic Scientists, has written a book supplying a frame of reference by means of which individuals can think, act, and vote intelligently in dealing with the important issues concerning atomic power. That there is great need for such an undertaking can be readily recognized, for only by understanding the basis and development of atomic energy can one judge the legislation and foreign policy that concern it.

Since the exploding of atomic bombs over Hiroshima, Nagasaki, and Bikini, many ridiculous notions about the origin, the na-

ture, and the secrets of atomic energy have been disseminated. Actually, as Professor Hecht points out, the subject, through the scholarly efforts of scientists all over the world, has had an orderly history and development. Hecht portrays this development in terms of the historic steps that were taken in going from the earliest questions about the nature of substances to the large-scale liberation of atomic energy. Clearly and simply, without assuming any previous knowledge of physics, chemistry, and mathematics on the part of his readers, he weaves a bright fabric of the light and dark threads of atomic analysis—packing factors, fast and slow neutron analyses, combining ratios of substances, Einstein's mass-energy equation, nuclear fission, and the chain reaction.

In addition to being able to grasp these analytical protrayals, the reader is able to make computations in terms of Einstein's mass-energy equation to obtain some indication of the possibilities of a uranium chain reaction in the production of atomic energy. If, for example, all the atoms in a pound of U-235 were fissioned, the energy produced would be over 400 billion billion ergs, or, in common units, 12,000,000 kw-h. Released slowly under control, this energy would furnish the electric current to keep 12 million 100-watt lamps going for a 10-hour day, or about enough to illuminate all the homes in New England for an evening. Released quickly, in a fraction of a second, it would have the explosive force of 10,000 tons of TNT. Pound for pound, U-235 could yield an explosive force 20,000,000 times more powerful than TNT; and, even if only 1 percent of the atoms in a pound of U-235 were to fission, it would still be equivalent to 200,000 times the explosive force of TNT.

It is more than likely that some academicians will censure Professor Hecht for oversimplifying the story of the atom. Nevertheless, his book, despite its lack of scholarly accessories, makes palpable the intricacies of a segment of science that comprises one of the most fascinating chapters in the history of the human race. As such, it is an invaluable contribution to laymen who conscientiously seek to understand nuclear fission, the better to utilize its motive and curative power as a new, worldservant.

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KNOW THEN THYSELF

The Life of a Chemist. Memoirs of Vladimir N. Ipatieff. Zenia Joukoff Eudin, Helen Dwight Fisher, and H. H. Fisher, Eds. V. Haensel and Mrs. R. H. Lusher, Translators. xv + 658 pp. $6.00. Stanford. Stanford University, Calif. 1946.

SCIENCE is not merely a body of accumulated knowledge, a system of facts and laws, but is in itself a creative force that permeates all human activities and, under the catalytic action of congenial brains and the pressure of historic events, brings forth ever-new knowledge and enlightenment. This dynamic concept of science is illustrated by the life story of the great Russian chemist Vladimir Nikolaevich Ipatieff, who is best known as the discoverer of pressure catalysis, although his scientific achievements are not restricted to this important field of organic chemistry.

In reading Ipatieff's autobiography one notices that it is not only the vividly told story of a long, eventful, and fruitful life and of an extraordinary and distinguished career, but also the history of chemical science during the last century and of the outstanding chemists of the last three generations, with most of whom Ipatieff stood in direct scientific and personal contact.

Ipatieff's early scientific career developed under the dominating influence of the other great Russian chemist, Dmitri Ivanovich

Mendelyeev, whose discovery of the periodic law of atomic weights laid the foundation of modern inorganic chemistry and nucleonics. As Mendelyeev was half a century ahead of the general progress of inorganic chemistry, so was Ipatieff fifty years in advance of organic chemistry by the discovery of the catalytic action of metals and metaloxides. In fact, catalysis, especially when applied under high pressure and at high temperature, was of greater practical importance to world chemistry and industrial development than was Mendelyeev's law, which for a long time remained in the theoretical realm.

In Germany Ipatieff studied under the master of organic synthesis, Adolf von Baeyer, and worked in his laboratory in Munich next to Richard Willstätter, the discoverer of chlorophyll, and Moses Gomberg, who was to become one of America's greatest chemists. In France Ipatieff was in contact with Pierre Berthelot, the founder of thermochemistry, as well as with Sabatier and Senderens, who were working on catalytic hydrogenation. But it was Ipatieff's scientific genius that brought catalytic action and thermodynamic effects together in studying the effects of such catalysts as iron, nickel, zinc, or alumina under pressures up to 200 atmospheres and at temperatures up to 600°C.

These experiments not only started a new chapter in organic and industrial chemistry by making possible the controlled composition and decomposition of organic compounds, but they also elucidated the origin of petroleum in nature and led the way to a better utilization of natural petroleum and to the synthesis of petroleum products from coal. Thus Ipatieff's achievements in the field of pressure catalysis were the foundation stone upon which a second generation of chemists in the industrially more developed countries of the world has built the enormous structure of industrial chemistry. It is this second generation of modern chemists with whom the Russian scientist was in close contact, and his autobiography proves conclusively that the amazing growth of chemical industry in our century is not so much due to the solitary work of individual scientists as to scientific cooperation and exchange of knowledge on an international basis.

It is this international cooperation of scientists in which Ipatieff ardently believes and to which he strenuously but unsuccessfully tried to convert a reluctant Soviet government, to whom he, a former Czarist Lieutenant General, had lent his services for purely patriotic reasons. He was Member of the State Planning Commission, Chairman of the Chemical Administration of the Soviets, and of many other technical and scientific committees. In these capacities he traveled widely in Germany, Belgium, France, and England. It is very revealing to note how intent the Soviets were at times to establish friendly relations with such exponents of capitalistic production as the I. G. Farbenindustrie and similar concerns. In the end, however, those men who worked upon order of their government for the establishment of better scientific and technical relations with foreign countries were themselves viewed with suspicion and distrust and strictly supervised and curtailed in their scientific activities. Even a scientist of Ipatieff's standing and international fame was not free from suspicion, and, after several of his colleagues and coworkers had been "liquidated," he felt it safer to leave his beloved homeland.

Now it is our good fortune to have Ipatieff, the indefatigable chemist, working and teaching here. He is Professor of Chemistry at Northwestern University and Director of Research of the Universal Oil Products Company in Chicago. This last interesting chapter of Ipatieff's life is not dealt with in the present autobiography, but it may be hoped that it will be written in due time. For, much as the great Russian

chemist has already given to the scientific and industrial world, he has still more to give. He has amassed an immense chemical knowledge and has also acquired, through long and bitter experience, the true wisdom that transcends the limits of any particular science and is applicable to all. We can truly take to heart what he says in the closing chapter of his autobiography:

> A Government has the right to ask a scientist to aid in developing some process which may be of great importance to the nation's economic life, and a scientist is obligated to help if he possesses sufficient knowledge. But neither the Government nor the scientist should ever forget that most scientific developments come from research which is itself completely divorced from any practical application.

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ACRES OF DIAMONDS

New Riches from the Soil. Wheeler McMillen. xii + 396 pp. $3.00. Van Nostrand. New York. 1946.

IN THE face of the impending starvation of millions in Europe, friends and foes alike, it is too bad the author of this book was not present at Potsdam to voice a strong protest against the unfortunate Allied edict condemning all German chemical nitrogen plants to destruction or to enforced idleness. Prior to the war, Germany accounted for 40 percent of the world's production of nitrogenous fertilizers using the famous Haber-Bosch process for fixation of atmospheric nitrogen. The major portion was exported to enrich the farms of other European countries.

Now, belatedly, wiser judgment has prevailed, and such plants as were not destroyed or dismantled are being reopened. Meanwhile, in response to frantic appeals for immediate aid from generals in command of the occupying forces, hundreds of thousands of tons of nitrogenous fertilizer are being exported from wartime synthetic ammonia plants in the United States, mostly at the expense of American taxpayers. The tragic explosion at Texas City of the French freighter *Grand Camp* originated in a cargo of ammonium nitrate destined for European relief.

Although the author emphasizes the transcendent importance of building civilization around a healthy agriculture, capable of producing ample foodstuffs, and praises the economic permanence which ensues, his main purpose is to portray the growth of chemurgic* industries and to stress their social significance. As editor of the *Farm Journal*, as joint founder and President of the National Farm Chemurgic Council, and as a practical farmer as well, Wheeler McMillen is exceptionally well qualified to do this. Admitting in his preface that he "is not a scientist . . . but perhaps a sort of evangelist," he points out that "twenty years ago [he] became convinced that mere law-passing could never assure a stable and prosperous American agriculture . . . the problem is not legislative but economic and scientific."

His faith in the limitless achievements of modern science for man's good is stimulating to those engaged in the profession, and reassuring to the general public. "The three great tools now available to agriculture which promise enlargement of human wealth," he concludes, "are the science of organic chemistry, the science of plant genetics and the art of the engineer."

"Probably about nine out of ten people in the world live and die in poverty," he continues. "This is not for lack of natural resources, but because of ignorance of

* *Chemurgic*, a combination of *chemi*, or "chemistry," from the black art of ancient Egypt, and *ergon*, or "work," from the fount of knowledge of ancient Greece. Coined by William J. Hale in his book *The Farm Chemurgic* (1934), its definition through usage is "to advance the industrial use of farm products through applied science."

them." He then follows with a wealth of convincing practical illustrations of chemurgic progress, particularly in the United States, which demonstrate that the author is a persuasive interpreter of science.

In philosophical vein McMillen challenges the reader with the logic of his observations:

> The vegetable kingdom reproduces itself. The mineral kingdom does not . . . agricultural communities a thousand years old can be found around the world. Extractive mineral industries leave ghost towns behind them: sound agriculture does not . . . ninety eight per cent of the material in the plant (annual or perennial) is the product of atmosphere and moisture, [plus a few mineral catalysts].

He paints a glowing picture of the hitherto unsuspected wealth of the vegetable kingdom as a permanent source of supply of raw materials for industry.

While commending governmental agencies for their sponsorship of fundamental chemurgic research and development through various state colleges and universities and through the four Regional Research Laboratories of the U. S. Department of Agriculture, the author strongly advocates private competitive enterprise as the best medium through which to translate the fruits of such research into commercial application. This will better assure the economic soundness of the program. His advocacy of incentive payments by the Federal government to encourage the domestic production, where feasible, of agricultural commodities now being imported (no doubt a wartime necessity) will not be accepted favorably by everyone; but he certainly is on firm ground when he proposes incentive payments to the farmer for planting "*soil-improving and erosion-preventing crops.*" With one-half our topsoil already washed into the seas, this remedy is sound insurance for future generations.

The last chapter is a plea for greater production as a force for peace. Though not attempting to be exhaustive, the author maintains that the principal basic cause of war is want of food and goods. These deficiencies, he urges, can be supplied by men of science if world statesmen will turn their attention from political remedies to economic preventives and use the tools modern science offers. "Growing things and making things pay better than taking things!"

The book is recommended to scientists as an example of lucid interpretation easily understood by the multitude—an example that might well be emulated—and to the general public as a tonic in these days of confused talk and thought. The farmer will find new hope in it, and the student might well consult it before choosing his vocation.

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PLAIN AND SIMPLE FAITH

Papago Indian Religion. Ruth M. Underhill. vi + 359 pp. $4.50. Columbia. New York. 1946.

FOR those whose curiosity would lead them to ask what a primitive religion is like, this readable and authentic account is highly recommended. Dr. Underhill has long been known for felicity of style, simplicity of presentation, and faithfulness to the record. One noteworthy characteristic is the large number of song and speech texts in fluent but obviously close translation.

The Papago occupy the desert lands of the Arizona-Sonora border. With the cognate Pima to the east, they comprise a somewhat distinct linguistic group in our Southwest, yet their culture is in general Southwestern (rather than Mexican or wholly distinct) and specifically of the Gila-Colorado River-Cáhitan subvariety. Until recently our lack of precise knowledge of Pima-Papago life left a bad gap in an otherwise reasonably thorough survey of South-

western tribes. Dr. Underhill's earlier *Social Organization of the Papago Indians* (1939), with the present volume and such data on their material existence which she may still have unpublished, will block in part of that blank area. We wish for just such excellent material on the Pima. Russell's *The Pima Indians* (1908), with which we make shift, is hardly more than an inconsiderable commentary on a museum collection, with detached, unexplained oddments—indeed, Dr. Underhill's record on the closely related Papago often clarifies the mystery of the Russell items.

Papago religion has no single, coherent core; hence the ethnographer must draft its subject matter as a set of uncoordinated beliefs and practices. The origin myth, as the author points out, does not serve as a cohering base for ritual (as it does for Navaho), though there is some counterflow between the two. The lack of relation stems first from the diversity of versions, each peculiar to the several Papago local groups, ostensibly learned by rote but subject to the vagaries of the accredited narrators, and, again, from the absence of a body of ceremonialists (as among the Pueblos) concerned with standardization and interested in welding myth and ritual into a consistent body of theological doctrine and practice.

The supernaturals of myth are not those of ritual, either in impersonation or as the target of prayer. Here function the ancient divine bestowers of ceremonies, the rain-controlling divinities, and animal spirit guardians who may be beneficent or otherwise, according to occasion. Contact with the supernaturals was through group ceremonies, directed by priests and for the common good, and by individual quest for power to overcome life's difficulties. In general, whatever the immediate need for which help was sought, all contacts were thought of as ultimately for the bringing of rain. The rites of the individual were those occasions when specific supernatural power was sought: the prime occasion was during the course of purification from defiling contact (as with the magically malevolent enemy) under the aegis of ritual instructors, when the supplicant was most favorably disposed to the reception of benefits via a vision from the spirit helpers. Some uniqueness of Papago religion lies in the utilization of these occasions—paralleled in neighboring tribes—as opportunity for the power quest.

Most of the ingredients of Papago religion are common to other tribes of the subarea, and, indeed, many are widely distributed over the Southwest. The Papago Rainmaking Ceremony, for example, is the familiar "wine"- (suhuaro) drinking celebration of neighboring tribes. It is here ritualized and rationalized on the principle that all ceremonials are directed toward rainmaking. "The idea is that the saturation of the body with liquor typifies and produces the saturation of the earth with rain. Every act of the procedure is accompanied with ceremonial singing or oratory describing rain or growth" (p. 41). The unique Papago (and Pima?) contributions to this elaborate complex of celebrative rites are rainmaking as motive, the presence of the village fetishes, a circling dance, perhaps the set speeches, and four representatives of different villages typifying the four rain supernaturals placed cardinally and accorded reverence. Yet there is little hint in this volume that the suhuaro-drinking celebration was common among the Southern and Western Arizona tribes and was, in fact, a Northern extension of a widespread Mexican drinking and narcotics complex.

It was not the author's intention to offer a comparative survey to place Papago religion in relation to surrounding cultures—save with regard to the Prayer-Stick Festival—but a Southwestern ethnographer is constantly stimulated to try his hand at it. The more so since Dr. Underhill, probably without intent, often phrases her material

as though unique to the Papago and derived by them in reaction to the impinging needs of an inhospitable environment and developed out of the traditional motivations they ascribe to their rites. To be sure, she frequently offers some parallels of minor items to other Southwestern groups, almost always to the Pueblos. But one would say that while these are justified, they tell only a partial story of relationships; for many of the elements—whole ceremonies, ritual components, minor practices—affiliate as well with groups other than the Pueblos, geographically placed in quite other directions.

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BRAVE NEW WORLD

UNESCO: Its Purpose and Its Philosophy. Julian Huxley. 62 pp. $2.00, cloth; $1.00, paper. Public Affairs Press. Washington. 1947.

UNESCO's main concern is with peace and security and with human welfare, in so far as they can be subserved by the educational and scientific and cultural relations of the peoples of the world." Julian Huxley, who was the Executive Secretary of the Preparatory Commission of UNESCO, and who is now the Director General of the organization, attempts to formulate briefly the basic philosophy for a United Nations Organization charged with the tasks outlined in the above quotation.

Huxley writes as a biologist, philosopher, and social scientist, in the great tradition of the family of naturalists of which he is a worthy descendant. He sees UNESCO as the next big step in the intellectual evolution of the human race. In contrast to the organizations that functioned under the League of Nations, UNESCO must go to the people and prepare them for universal service as citizens of the world. UNESCO takes the lead, as the world moves gradually—as in the end it must, if we are not to perish—toward political unification. UNESCO should help to achieve the maximum progress in the minimum time, and it is for this reason that Huxley urges for UNESCO an evolutionary background.

Huxley has no illusions about the ability of the entire human race to take full advantage of the total available worldpool of knowledge, art, and culture. UNESCO should not aim at quantity, to the detriment of quality, but it should provide to all who desire it an opportunity to share in the common pool. We need on a world-wide scale the same equality of opportunity that we are striving to achieve on a nation-wide scale under our democratic system. UNESCO must "let in light on the world's dark areas."

The pamphlet is divided into two parts. In our brief summary we have quoted from the first part, that dealing with the background of UNESCO. This is a moving document that should be read with care and pondered over by all who wish to see the United Nations succeed. The second part, which describes the program, is not on the high level of the first part. It is a not-too-happy blend of basic philosophy and of itemized programs, which left this reviewer confused and dissatisfied. UNESCO has a fine program of which the major portions are rehabilitation of schools and institutions in war-devastated areas; a world-wide attack on the problems of illiteracy; a program of promoting international understanding through teachers' conferences, exchanges, and the like; and the over-all study of the potentialities of the Hylean Amazon basin. These have not been adequately treated in the pamphlet.

Huxley's discussion is a valuable one, but it would be unfortunate if one's only contact with the program of the new organ-

nization should be through this booklet. Those who are really interested in learning of the plans and projects of UNESCO should supplement the reading of Huxley's pamphlet with other material that is now available. Copies of the report published by the U. S. National Commission on UNESCO, the Draft Reports of the UNESCO Congress in Paris of last year, and a report on the National Conference on UNESCO held at Philadelphia in March of this year can be obtained by writing to the Office of the UNESCO Relations Staff, State Department, Room 304, Walker-Johnson Building, Washington 25, D. C.

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THE SEAR AND YELLOW LEAF

Aging Successfully. George Lawton. xiv + 266 pp. $2.75. Columbia Univ. Press. New York. 1946.

IN THE past few years an increasing interest has developed in the "problems" of old age. Dr. Lawton attempts in this book to present a readable discussion of important issues, aimed at the older reader himself. Emphasis is placed on aging as a process of change, with its advantages and disadvantages and its realistic opportunities. By making a reasonable effort old people can adapt themselves quite adequately to their new circumstances if they have been developing a wide range of interests and abilities in youth.

Discussion is matter-of-fact and straight to the point. Proposed solutions are based on the author's wide clinical experience and a knowledge of pertinent scientific literature. This book may well serve as a handbook of later maturity, adapted to the interests and reading ability of its audience.

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HERPETOLOGY FOR AMATEURS

Reptiles and Amphibians of the Northeastern States. Roger Conant. 40 pp. $1.00. Zoological Society of Philadelphia. 1947.

MR. CONANT, Curator of the Philadelphia Zoological Garden, has constructed a nontechnical resume of the snakes, lizards, turtles, frogs, toads, and salamanders of the Northeastern states that furnishes instant identification for all these interesting animals through photographic illustrations of every species. In addition, he has furnished a check list of species and interesting chapters on each group; a chapter on the treatment of snake bite; another for the identification of baby turtles, which differ surprisingly from their parents; and a chapter on the care of captive specimens.

This pamphlet is recommended for the individual who keeps pets of this nature, the observant hiker, Boy Scouts, science teachers, and nature enthusiasts.

The size of the pamphlet and texture of the paper make this edition a desk item. It is to be hoped that Mr. Conant will publish a pocket-sized field guide, using the same excellent illustrations and descriptive matter.

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THE PLANTS THAT LEAD A DOUBLE LIFE

The Nature and Prevention of the Cereal Rusts as exemplified in the Leaf Rust of Wheat. K. Starr Chester. xiv + 269 pp. Illus. $5.00. Chronica Botanica. Waltham, Mass. Stechert-Hafner. New York. 1946.

WHEAT is probably the most important of man's food crops, and the three rusts that attack it (stem rust, leaf rust, and stripe rust) are the most serious diseases affecting that crop. Despite the immense amount of research work done on

these rusts in English-speaking countries in the past three decades, there has appeared in English no monographic treatment of any of the cereal rusts comparable to *Der Schwarzrost*, published in Germany in 1937, or Naumov's *Cereal Rusts in the U. S. S. R.*, produced in Russia in 1939.

Dr. Chester's book fills this want in part, but in part only, for despite the title *The Cereal Rusts*, by which it is advertised and sold, it is largely confined to one of the three rusts—leaf rust of wheat.

This restriction of scope is, however, actually an advantage from the point of view of the student of the rusts, for it has permitted a thorough and exhaustive treatment of the subject such as would not have been possible if the other cereal rusts had been included.

To most people, at least in North America, rust of wheat means stem rust, partly because of the news value of its swift and often devastating epidemics, and partly because of its well-known association with an entirely different host plant, the common barberry. The author has nevertheless made a convincing case that in the world as a whole leaf rust is the more destructive of the two. Because of the insidious quality of its parasitic behavior, the true importance of leaf rust was not recognized in North America for many years after scientists had turned their attention to the control of stem rust. In countries where stem rust was relatively unimportant this recognition came sooner. In Germany and the U. S. S. R. scientific attention has been concentrated for many years past on the control of leaf rust. Although control of this, as of other cereal rusts, must come chiefly through the breeding of rust-resistant varieties, a thorough understanding of the nature and behavior of the rust organism is an essential prerequisite. This realization has led to intensive investigations concerning this rust in most of the important wheat-growing countries of the world.

The extensive literature on leaf rust, scattered through the scientific and agricultural journals of a dozen or more countries, is admirably summarized in Dr. Chester's book. Particularly valuable is the review of the numerous and many-sided investigations carried out in the U. S. S. R., with which the author has made himself thoroughly familiar by his translations into English of a large number of Russian scientific papers. Well summarized also are the important studies of Gassner (to whom the book is dedicated) and his associates, who have contributed much to our too-scanty knowledge of the chemical basis of rust resistance and susceptibility. It might be mentioned in passing that both the German and the Russian investigators have placed a greater emphasis on fundamental studies than has been the practice in English-speaking countries.

The book is by no means, however, a mere summary of the literature concerning leaf rust. The author's whole handling of his subject is pervaded by a strong sense of logic which has led him, wherever possible, to create order out of chaos. In several instances he has ransacked the literature for data bearing on some point of importance and has built up tenable conclusions from numerous scattered experiments and observations. One such case is his establishment of a definite relationship between leaf-rust intensity at different stages in the growth of the wheat plant and the resulting loss of yield. Another of the seemingly chaotic situations he has tackled is the vexing question of the specialization of the rust into a large number of pathogenically distinct entities or physiologic races. His proposal that the 129 races in the "International Register" be grouped on the basis of similarities into 44 race groups cannot be resisted on logical grounds and will, if it gains general acceptance, simplify considerably the task of race identification. The identification of physiologic races is, however,

essentially a service to plant breeding, and on its serviceability in that respect the scheme will stand or fall.

Though the book is primarily written for the specialist in plant diseases, the author has nevertheless kept the elementary student in mind and, for his benefit, has explained most things from the ground up. All in all, it is the most notable book of its kind that has been published in English for many years past.

There is a bibliography of about 500 references, as well as adequate author and general indices. The editing conforms to the high standard set by Frans Verdoorn for the *Annales Cryptogamici et Phytopathologici*, to which series this book belongs.

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REVERIES OF A NATURALIST

The World Grows Round My Door. David Fairchild. xii + 347 pp. Illus. $5.00. Scribner. New York. 1947.

THERE is no preface for this book, which is perhaps reasonable, since it is essentially a book of reminiscences. The author, however, does say in his first chapter that he hopes "to show . . . that there is a fascinating world of living things. . . ."

In spite of its title, the book is primarily about people, the Fairchilds themselves, their children and their children's children, and the endless stream of the great and the near-great who have known the Kampong or have had a share in the Florida and other phases of the author's life.

Not content with this, Fairchild goes back to his boyhood and briefly sketches the early years in Michigan and Kansas, school and university days, and then that astonishing first trip abroad. The impact of these first impressions is recounted with astonishing naiveté, and indeed one might say that this amazing capacity for looking at new sights with uncritical enthusiasms has never perished.

To a plantsman, the book will be most unsatisfying if he wants to read about plants, although the many fine pictures, most of them taken by the author, will console him somewhat. Endless things are mentioned, but very little is said about them. Palms, tropical vines, succulents, citrus fruits, kudzu, soybeans, sausage trees, bael fruit, mangoes. avocados, mangosteens, all remind us of the catholic tastes of the author and of his puckish pleasure at the discomforts of those who had to eat whatever he presented. (It is notable that children most often refused—and were least censured.) No full pictures emerge, however, either of the Kampong as a whole or even of snatches of the native landscape from which the treasures have been wrested.

The wideness of his travel is recorded in the mention of such far-separated places as Japan, France, Java, the Gold Coast, French West Africa, New Guinea, Guatemala, Colombia, the Celebes, Mexico, Brazil, Sumatra, New Zealand, Nova Scotia. Many more could have been named.

The growth of the Kampong, Fairchild's present home in Florida, is described at considerable length, but more could well have been said, since it is an estate with special significance: it reflects not only the traveled background of the author, but also special adaptations to the local site and conditions that are particularly well done.

If we will cast aside all preconceived notions as to what the book should or might be and follow "DF," as we all affectionately call him, wherever his errant fancy may suggest; if we will accept his kaleidoscopic enthusiasms one after another; if we will indulge his penchant for the personal and smile at his passion for the beauty of the moment while he labors to record forever the person and his deed—if we do all this, we can follow intimately in many details

the full and varied life that the author still enjoys.

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SHORT PERIOD SOLAR VARIATIONS

The Sun's Short Regular Variation and Its Large Effect on Terrestrial Temperatures. C. G. Abbot. 33 pp. 30 cents. Smiths. Mis. Coll., Vol. 107, No. 4. Washington. 1947.

AFTER his retirement in 1944 as Secretary of the Smithsonian Institution, Dr. C. G. Abbot, now a Research Associate of that Institution, has continued his work of correlating the variations in the solar constant with the temperature variations at the earth's surface. His latest work begins with the following statement:

> I propose to show that there is a regular period of 6.6456 days in solar variation, and that terrestrial temperatures respond with changes from 2° to 20° F. in exactly the same average period of recurrence. While the sun's variation appears to be perfectly regular in phase, always recurring on the day predicted, the terrestrial responses come sometimes for a month or more in succession from 1 to 3 days early or late. This, which by mechanical analogy we might call backlash, is doubtless the circumstance which hitherto has prevented meteorologists from recognizing the nature of this large temperature variation. When examined with the knowledge of the 6.6456-day solar period, the temperature effect is indeed so strikingly obvious, as the reader may see from figures 3 and 5, that no one could doubt that it is both real and a major element in weather. Meteorologically, this regular average periodicity appears to be a new discovery. It is not to be confused with temporary weather periods, ranging from 3 to 7 days in length and changing their phases from time to time, which have been discussed by Clayton [*et al.*].

In 1936 Dr. Abbot published two papers on the dependence of terrestrial temperatures on solar variation. The amplitude of the temperature was about 10°F., and the variation of the solar constant was about 0.7 percent of its value. Meteorologists, physicists, and astronomers have to this day remained skeptical as to whether the Smithsonian observations of the solar constant really were accurate enough to establish solar variations from day to day. In his latest study Dr. Abbot has exclusively used the accurate determinations of the solar constant made at Montezuma, Chile, from 1924 to 1944. In his previous analysis only the larger variations could be discerned individually, but in this recent study excessive changes were omitted as spurious. The period in the solar variation was determined with high accuracy, but the amplitude was found to be only about 0.13 percent of the solar constant.

The amplitude of solar change is so small, compared to the average amplitude of temperature change associated with the 6.6456-day periodicity, that Dr. Abbot is inclined to attribute the terrestrial temperature effects to some indirect action, such as fluctuations in the amount of ozone in the higher atmospheric strata. Since the phases of the temperature recurrence remain almost unchanged in any one month, and the variation of amplitude is not often excessive within that interval, temperature forecasts of the order of a month in advance appear to be feasible with the aid of the cycle newly discovered by Dr. Abbot. Meteorologists now have a chance of testing the practical value of "Abbot's Cycle."

GUSTAF STROMBERG
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Comments and Criticisms

JOSÉ LONGINOS MARTÍNEZ

The article by Carlos E. Chardon in the March SM on the Naturalists of Tropical America was of great interest to me because I have always felt that the contribution of the Latin Americans themselves to the natural history of the lands which they settled has been too much neglected by the historians of science. One must suppose that the omission of the names of Francisco Herrera and Carlos de la Torre can be accounted for by the fact that the former was recently the subject of an illuminating article in the SM and the latter is still alive. Perhaps they will be covered in the book which the author contemplates writing.

There is one pioneer naturalist whose career is not covered in this article and who has been consistently neglected by practically every writer since his day. I am referring, of course, to José Longinos Martínez, as he is commonly known, though there is sufficient documentary evidence to indicate that his Christian name was Joseph. In the Archives of the Indies at Seville there is an invoice of mammals, birds, and reptiles which he sent back from San Borjas, in Baja California, to the Archbishop of Seville in 1792. In a contemporary newspaper published in Mexico City is an announcement of the opening of a museum of natural history under his direction, in which the plants and animals are arranged according to the Linnaean system. And a document in the same city signed by Fernando Eliya states that on his return voyage he picked up the famous botanist Joseph Longinos Martínez at an unnamed California port (which we now know to have been San Diego) and disembarked him at San Blas in 1792.

Some years ago Dr. Henry R. Wagner discovered a manuscript copy of Longinos' account of his travels, which is now in the Huntington Library, where I have examined it. According to Dr. Lesley Byrd Simpson, who translated it, it is not the original, but the work of a copyist, whose ignorance and carelessness are shown by the large number of grammatical errors, misspelled words, etc. in the narrative. Further, it is inconceivable that Longinos could have visited the localities which he names in the order set out in the document. For this reason the manuscript was at one time considered to be a rather clumsy forgery, but shortly after its publication Mrs. Winifred Davidson, the historian, discovered on the baptismal record of the San Diego Mission an account of the baptism of an Indian boy, whose father was the famous botanist Joseph Longinos Martínez, "naturalized by his majesty." The fact that Longinos was a naturalized citizen is important, for it explains his disdain for the Spanish Franciscans and his admiration for those from Catalonia and Germany. If, then, he was foreign-born of what nationality was he? The fact that his paternal patronymic was Greek suggests to me that he may have been of mixed Greek and Spanish parentage—but that theory is as yet an unproved speculation. His knowledge of the Linnaean system suggests that he may have been a student under the Swedish master, but his name does not appear in the list of pupils of Linnaeus published by Dr. Jackson of the Linnaean Society.

The Longinos narrative suggests that he was a keen observer of all phases of nature, not only as botanist and zoologist but also as mineralogist and anthropologist. He was the first to record observations on the life, habits, and thought of the California Indians, as well as the first to make a chemical analysis of the numerous mineral springs of the state. At times given to exaggeration (what Californian is not?), he nevertheless made detailed and complete observations. Yet today he is practically forgotten, the only attempt to preserve his memory, as far as I am aware, besides the translation of the anonymous copyist, being a bronze plaque on the wall of the Junípero Serra Museum of History in Presidio Park in this city.

It is my hope that Dr. Chardon will be able to unearth further data about Longinos in his forthcoming work, as well as about such significant writers as Molino and Hupé, who exist today only as names in bibliographic references.

JOSHUA L. BAILY JR.
San Diego, Calif.

GEOLOGY SLIGHTED

I realize that the excellent article by Dr. Brandwein on "The Selection and Training of Future Scientists," which appeared in the March SCIENTIFIC MONTHLY, is descriptive of a practical application of the scientific method to precollegiate instruction. However, to scientists whose major field of interest is geology, it must be a disappointment to find no mention of that earth science, a most basic one, as being included in preliminary work done in the training of "future" scientists in the Forest Hills

High School. It is believed that there is as great a need for the education of future scientists in geology as in any other field. The inclusion of geology in a program such as that outlined by Dr. Brandwein is, because of the very nature of that science, practical, logical, and highly desirable. An interest in rocks and minerals is inherent in the average teen-age student, and some encouragement of this interest along the lines suggested in the article will do much to develop those students best fitted for more advanced training and a career in that science, and to provide a broadened vision for those who eventually go into other fields. The future role of geology in the various forms of human endeavor may be expected to be a greater one, and a precollegiate program in this respect seems highly desirable for many reasons.

THOMAS G. MURDOCK

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JUNIOR ACADEMIES OF SCIENCE

I was very much pleased with the summary of Junior Academies of Science published in THE SCIENTIFIC MONTHLY [April 1947]. The movement has great possibilities. Texas organized in 1935, and in 1937 I presented the first charter from the Texas Academy of Science. In the ten-year interval the organization has greatly increased its membership and activity. The local Galveston club has grown to about five times its birth weight. For several years I gave a scientific book as a prize to the leading member at the end of the year. This year I am offering membership in the A.A.A.S. and a subscription to THE SCIENTIFIC MONTHLY in the hope that others may do likewise. Miss Rose Mary Strain is the recipient this year. Her interest is psychology.

Texas Academy of Science is almost unique in having a Collegiate Academy for undergraduates as a feeder to the Senior group. The Collegiates and Juniors each have their own publications, and their own meetings at the time and place of the annual meeting. They are free to attend any meetings they choose.

This year Texas Academy of Science is attempting to establish permanent headquarters and hire a business manager and editor. A central theme has been adopted for the Academy by approval of a Council on Conservation, with each Councillor serving as a center for collection, presentation, and publication of data in a specific field. The project is of considerable interest to Governor Jester. The Council will continuously survey—

1. The health of the people, physical and mental.
2. The genetic composition of the state with attention to eugenic and dysgenic factors.
3. The effect of social and economic institutions and ideas on the public welfare.
4. Conservation of soil.
5. Water resources.
6. Oil and gas.
7. Sulphur and minerals.
8. Grazing and forest lands.
9. Marine resources.
10. Wildlife.
11. Archeological and paleontological sites.
12. Parks.

JOHN G. SINCLAIR

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I have found THE SCIENTIFIC MONTHLY so much more valuable and interesting recently than heretofore that I cannot refrain from writing to express my appreciation for its great improvement.

It is gratifying to note that the magazine now gives increasing attention to the general problems of science rather than dealing entirely with specialized fields. To the extent that specialized fields are treated, I am happy to see that the physical sciences are beginning to receive a reasonable share of the space.

My profession is physics; one of my avocations is acting as adviser to the Junior Astronomy Club, Hayden Planetarium, New York City. In this connection, I was especially interested in the articles relating to junior science in the April issue. Along the lines suggested by you in "The Brownstone Tower," I have felt that youngsters interested in science would find THE SCIENTIFIC MONTHLY interesting and valuable and I have made my copies available to Junior Astronomy Club members. It seems to me that many A.A.A.S. members could be encouraged to spread the use of their copies through school libraries and in other ways. Another method of getting SM into the hands of youngsters would be the establishment of junior or student membership in the A.A.A.S. at reduced rates.

JAMES B. ROTHSCHILD

Wharton, N. J.

Technological Notes

Must Be More than Spectacular. An idea with novelty constitutes an invention, but hard work and attention to painstaking detail are generally necessary for the innovation to be a success. Often we hear only of the "spark of genius," as a court once described it, and forget the dogged details.

Dusting insecticides on growing crops by airplane is novel and romantic. Young Lindbergh can come swooping out of the clouds, and straightway the boll weevil is vanquished—or so we may think. But Dr. George Decker, of the Illinois Natural History Survey, reminds us that it's not so simple. Research, he says, is necessary to devise the best type of plane to spread the compounds properly, and the materials themselves need to be specially formulated for that method of application.

The problem touches farmers, insecticide manufacturers, airplane designers, and the Civil Aeronautics Authority. Landing strips should be handy. Planes and pilots must not be jeopardized by unsafe flying conditions. Dusts shouldn't drift off the crop being sprayed or settle heavily down the middle of the swath. Such problems have to be licked, says Dr. Decker, or people will lose confidence in this way to fight insect pests.

Home Hardware. Nowadays there is no excuse for ignorance. So many agencies, government and private, furnish information in attractive packages that anyone can be enlightened on almost any subject. The only drawbacks are lack of filing space and shortage of time for reading and attention.

The reason for the foregoing observation is "Hardware for the Home," an illustrated circular of business-letter size already punched for binding, one of a series on small homes published by the University of Illinois. The University emits a publication in this series every five days, the mailing statement says, so that one agency furnishes an enormous amount of enlightenment.

The hardware in this case is such articles of convenience as locksets and doorstops. Check lists and drawings show just what is needed and how it will look and the method of installation. The newest in locksets is the one that can be installed by just cutting a notch in the door, though the tubular lock is probably the most popular type. There is a reminder that $25 extra will generally buy the very best in hardware for a house, and that solid brass and bronze wear excellently and become more beautiful with use.

After Cataract. Eye operations, which to the layman, at least, are miracles of skill and delicacy, in about a quarter of the cases are removal of the crystalline lens to relieve cataract. The person who has lost the lenses of his eyes (called an aphakic) must use glass substitutes. What might seem to be an advantage, according to an American Optical Company release, is that the aphakic can see by ultraviolet light. The lensless eye is 1,000 times as sensitive as the normal eye to light of 365 millimicrons. However, the u.v. may be injurious. American Optical has announced a new lens that strains out the u.v. A further advantage claimed is that the new lens, made thin around the rims, weighs only half as much as the usual thick lenses supplied patients who have had cataract operations.—M. W.

The Brownstone Tower

In an editorial note on page 89 of the July issue I introduced a new monthly page entitled "Technological Notes." I pointed out that these notes on the passing scene are being written by "a friend," whom I now present to our readers. M. W. stands for Merrill Weed, a friend indeed to me and the SM. I met him first before the war when I was Professor of Entomology at The Ohio State University and he was Editor of the publications of the O.S.U. Engineering Experiment Station. He also wrote a four-page monthly leaflet called *Science and Appliance* for the O.S.U. Research Foundation. *Science and Appliance,* which he continued to write while away from the campus in military service and which he still carries on, became noted for its interesting information culled from many sources and for its breezy style. As some of the members of our Publications Committee were familiar with it, they did not hesitate to accept Mr. Weed's offer to write a page of similar material each month for the SM.

Every issue of the SM's volume 65 (July–December, 1947) will contain something on the Chicago Meeting of the A.A.A.S., December 26–31, 1947. In the September issue Dr. John M. Hutzel, our Assistant Administrative Secretary, will take our readers behind the scenes and describe the intricate preparations that must be made long in advance for each annual meeting of the A.A.A.S. In the October issue the special duties of the manager of a convention bureau will be described by the man who served in that capacity at the last Boston Meeting. The December issue will consist largely or entirely of contributions from scientists in the Chicago area and, of course, will stress the meeting and the scientific institutions that will serve as hosts.

In the heat of early summer Dr. Hutzel has been working furiously on preparations for this winter meeting. Those who read his forthcoming article may realize for the first time that an annual meeting is expensive, not only to the individual who attends it but to the organization responsible for it. It is estimated that the Chicago meeting will cost $35,000. Previous experience shows that expenditures for this meeting will exceed income by about $14,000. The A.A.A.S. no longer has a reserve for the absorption of such deficits. Therefore something must be done to make the meeting self-sustaining. Since the affiliated societies who meet with the A.A.A.S. do not contribute directly to the meeting expenses, it seems reasonable and just that all those who attend the meeting, whether members of the A.A.A.S. or not, should pay a registration fee sufficient to cover expenses. Consequently, the secretary of each cooperating society has been requested to propose to his executive committee that a resolution be passed requiring attendance at its sessions be restricted to those who register with the A.A.A.S. for the meeting. Responses from the secretaries have been favorable, but they must have the informed support of their members. Therefore we hope that every reader who attends the Chicago meeting will register, even though his society may not require it. In this equitable manner, with little cost to any individual, everyone present can contribute to the success of the meeting.

F. L. Campbell